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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 12 MARTIN GOLAND *Editor* DECEMBER 1953

EXPERIMENTAL STRESS ANALYSIS

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INTRODUCTION

THE ultimate aim of the science of mechanics is the complete rationalization of a problem. In the field of stress analysis such an approach is often impossible. Uncertainties exist which may invalidate an analysis because the basic assumptions, upon which the analysis is based, are not all-inclusive. Differences between calculated and actual stresses result from one or more of the following:

The material is assumed to be homogeneous and isotropic. If the dimensions of the stressed solid are large in comparison with the size of a single crystal, the assumption of homogeneity is warranted. If the crystals are oriented at random the material may be considered to be isotropic. In certain problems the size of the body is not large in comparison with that of an individual crystal. Mechanical operations such as rolling or forging may yield a preferred orientation resulting in a state of anisotropy.

The material is assumed to obey Hooke's Law. Instruments capable of measuring extremely small displacements have been developed, and, with precise instrumentation, it is noted that the assumed linear relationship between stress and strain is nonexistent for certain materials.

The deformations are assumed to be small. Many problems are of such a nature that this assumption is not consistent with the facts.

Stress Concentrations. If stress concentrations, due either to a discontinuity of loading or of the boundary, are present, the usual analysis will not predict the maximum stress in the region of the discontinuity. If stress concentrations occur in a material which behaves in a ductile manner, the stress concentration will be relatively unimportant, for static loading. For alternating and dynamic loadings the stress concentrations must be known. For materials which exhibit a brittle type of behavior, stress concentrations must be considered for all types of loading.

Residual Stresses. Even in the instances in which the previous history of a structure is known, which is very rare, the analytical approach to residual stress determination is definitely limited. Since these residual stresses are frequently of importance, the experimental methods of stress determination must be employed. The desirable and undesirable effects of residual stress in dimensional stability, fatigue characteristics, stress corrosion, to mention a few, are well known.

Temperature. In many problems the temperature range, the temperature gradient, or both, must be given careful consideration. The properties of the material may or may not be known for the conditions which will be encountered.

Loading. The actual load which may be imposed may be unknown. Under such circumstances, we must admit that calculated stresses are really estimated and not true stresses.

Nature of the Loading. Many of the equations developed by analytical solutions are based on the assumption that the load is gradually applied. Any dynamic effects caused by the loading introduce certain imponderables. Assumed variations in the nature or in the area of application of the load may yield erroneous results in an analysis.

Continuity. In the analysis of many structures the continuity is estimated and the analysis pursued on the basis of the assumed conditions. If there is a variance between actual and assumed conditions we must expect that actual stress will differ from calculated stresses.

The afore-mentioned factors, and there are others, must be carefully considered if we are to arrive at a satisfactory and economical design. If we neglect such factors, in order to permit a mathematical solution, will the results be valid? We, as engineers, must clearly see that mathematics cannot remove the uncertainties involved in the assumptions which permitted the problem to be brought within the realm of a formal solution. The results are as good as the assumptions—no more, no less.

These statements are not meant to imply that formal analyses are worthless. Far from it—it is an extremely powerful approach to the solution of many stress distribution problems. Analyses based on the formal theory of elasticity have aided immeasurably in the study of the behavior of materials.

The techniques developed in experimental elasticity must be looked upon as additional tools which, if used intelligently, can supplement the knowledge obtained from a mathematical analysis.

Experimental elasticity is not a panacea. It can be used, however, to extend our knowledge of the behavior of materials under stress and perhaps, in the final analysis, eventually supply the in-

formation which will permit a more realistic mathematical solution to many stress problems.

THE PRESENT

Although experimental elasticity has always been considered, and developed, along with the formal theory of elasticity, advances in the technique and instrumentation fields, which have occurred within the past twenty-five years, have centered a considerable amount of attention on experimental methods.

Well-established and proved procedures have been evolved, and more or less standardized equipment and instrumentation are commercially available. Methods in common use may be broadly listed as follows:

Deformeter Methods. Deformeter methods are of particular use in the study of statically indeterminate structures. A model, usually made of cardboard or celluloid, so constructed that the stiffness of the model is proportional to that of the prototype, may be subjected at any desired section to known translations and a known rotation. The deflected shape of the model is then the shape of the influence line for the force or couple which produces the translation or rotation. The Begg's deformeter is typical of this type of equipment.

Mechanical Strain Gages. These gages, which may be obtained commercially in various gage lengths, are really displacement gages. Typical of those in common use are the Huggenberger tensometer, the Porter-Lipp, and the Berry strain gage.

Mechanical-Optical Strain Gages. The noteworthy example of this type of gage is that developed by Dr. L. B. Tuckerman of the National Bureau of Standards. This gage is rugged in construction and may be obtained in relatively short gage lengths. It has a high degree of precision which warrants its use as a comparison standard in calibrations.

Electric Strain Gages. These may be of the capacitance, inductance, or resistance type. The bonded wire resistance strain gage is probably the most commonly employed. This gage is light in weight, easy to mount, and is quite reliable. The necessary instrumentation, for either static or dynamic applications, is commercially available.

Photoelasticity. This method is based on a principle discovered by David Brewster in 1912. He observed that light in passing thru an optically isotropic solid suffered a double refaction when the solid was stressed. Photoelasticity as applied to two-dimensional problems has now reached a high state of perfection, and certain problems involving three-dimensional stress states have also been successfully attacked using this method.

Brittle Lacquers. Strain-sensitive brittle lacquers have been developed and are commercially available. This lacquer, when sprayed on a structure and aged properly, will crack as the structure is distorted under load. The crack pattern yields qualitative and, under carefully controlled conditions, quantitative information on the stress field. The cracks occur along normals to the principal tensile strain directions.

Transducers. Special devices are available, commercially, for the measurement of quantities such as force, pressure, velocity, and acceleration. The sensing element very often consists of specially designed electrical circuits which provide a voltage or current output which is proportional to the quantity being measured.

The Analogies. Very often the characteristics of two or more physical phenomena can be expressed in exactly the same mathematical form. Such physical systems are said to be analogous. The membrane analogy used in the study of pure torsion is a good example. Electrical analogies for the torsion of bars having a varying circular cross section have been applied successfully. The electrical analogy has also been used to determine stress concentration factors for circular shafts of two diameters connected by a circular fillet. It is also feasible to represent the most general elastic stress field by a system of electric networks. Electric network analogies have also been applied to the solution of pin-connected frameworks both of the statically determinate and statically indeterminate type. The analog approach has been employed in the design of many modern computers.

Other Devices. The electronic micrometer, a vacuum tube in which the plate may be displaced relative to the grid, and the differential transformer, which gives a voltage output proportional to the motion of the movable core, are useful for displacement measurements. The photoelectric strain gage and the optical interferometer serve the same purpose. The latter may be used as a calibration standard.

A large portion of the experimental information which is being taken today is recorded automatically. Much of the information is recorded in the form of oscillographic records. The compiling of point-by-point information from such records is indeed a tedious and trying process and has led to the development of several forms of mechanical and electrical analyzers.

Within relatively recent years, a pneumatic instrument has been developed and applied as the amplification element in strain gages, inspection gages, flatness gages, etc. The magnification and sensitivity are both very high and the calibration of the system is quite stable. In terms of pressure changes, measured in inches of water, magnifications of the order of 30,000 have been obtained with no mechanical leverage used. Excellent results have been obtained in strain measurements in which gage lengths of 1/8 inch and less have been employed.

THE FUTURE

We may reasonably expect improvements in all existing methods and instrumentation. The use of the analogies will become more common. A strain-sensitive paint, which will permit the rapid study of stress fields by using a probing technique, will, no doubt, be developed within the next decade. Increased attention will be given to the methods used in measuring temperature and temperature gradients because of the pressing need for knowledge of the properties of materials at elevated temperatures. Such information is demanded by activities in the fields of atomic energy, jet engines, and gas turbines. Shortages in certain critical materials, vital to our national welfare, may supply the motivation for increased activity.

At present we can see no plateau upon which this branch of science can rest. We can be certain the ascent may be accelerated by the proper correlation of theoretical and experimental studies.

Books Received for Review

ALLIS, W. P., and HERLIN, M. A., Thermodynamics and statistical mechanics, New York, McGraw-Hill Book Co., Inc., 1952, viii + 239 pp. $6.

BOUMAN, C. A., Properties of lubricating oil and engine deposits, London, St. Martin's Press, 1950, viii + 170 pp. $3.50

BROWN, W. D., Parachutes, London, Sir Isaac Pitman & Sons, Ltd., 1951, xiii + 322 pp. $8.50.

CHAZY, J., Cours de mécanique rationelle. Tome I. Dynamique du point matérial, Paris, Gauthier-Villars, 1952, 510 pp.

COULTHARD, W. H., Aircraft instrument design, New York, Pitman Publ. Corp., 1952, viii + 309 pp. $7.50.

DUNCAN, W. J., Physical similarity and dimensional analysis, London, Edward Arnold & Co., 1953, vii + 156 pp. $6.

FABER, O., Reinforced concrete, London, E. & F. N. Spon, Ltd., 1952, 232 pp. 30s.

GREEN, H. S., The molecular theory of fluids, New York, Interscience Publishers, Inc., 1952, viii + 264 pp. $5.75.

HOELSCHER, R. P., ARNOLD, J. N., and PIERCE, S. H., Graphic aids in engineering computation, New York, McGraw-Hill Book Co., Inc., 1952, viii + 197 pp., 1 plate. $4.50.

JOST, W., Diffusion in solids, liquids and gases, New York, Academic Press, Inc., 1952, xi + 558 pp. $12.

MCLACHLAN, N. W., Theory of vibrations, New York, Dover Publications, Inc., 1951, vi + 154 pp. $1.25.

MCSHANE, E. J., KELLEY, J. L., and RENO, F. V., Exterior ballistics, Univ. of Denver Press, 1953, xiv + 834 pp. $12.

MILLER, K. S., Partial differential equations in engineering problems, New York, Prentice-Hall, Inc., 1953, viii + 254 pp. $4.75.

POLI, A., Calcul des conduites d'eau avec cheminées d'équilibre, Paris, Gauthier-Villars, 1953, x + 78 pp., 12 diagrams.

RAUSCHER, M., Introduction to aeronautical dynamics, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, xv + 664 pp. $12.

SCHRAGE, R. W., A theoretical study of interphase mass transfer, New York, Columbia Univ. Press, 1953, viii + 103 pp. $3.50.

WANG, C.-K., Statically indeterminate structures, New York, McGraw-Hill Book Co., Inc., 1953, x + 424 pp. $7.50.

Communications

Concerning AMR 6, Rev. 816 (March 1953): J. R. M. Radok, The theory of general instability of cylindrical shells

The second part of this review reading: "Starting with a double Fourier series, etc.," is not correct. In fact, the order of the determinant depends only on the number of reinforcing members in the cylinder. The theory is not only simple in principle but also in application, and the conclusion drawn by Marguerre that no further applications were given because of the complexity of the theory is unjustified. The reason was that I personally was not interested in numerical application at the stage when the paper was written. This paper was presented at Istanbul and I indicated there that application of the same ideas to rectangular plates leads much more quickly and more easily to results obtained by the energy method some years ago by Cox. In the meantime, I have written up this work in another report to be published shortly. J. R. M. Radok, Australia

Concerning AMR 6, Rev. 1366 (April 1953): R. W. Haywood, The thermodynamic properties of saturated water

The review incorrectly infers that Callendar's equation for the enthalpy of saturated water is used to prove a graphical representation of water properties on the temperature-entropy plane. Mr. Haywood's proof of the representation is more general than that previously used and is developed without recourse to any empirical relation such as the Callendar equation.

W. H. Roberts, Jr., USA

Concerning AMR 6, Rev. 1815 (June 1953): J. L. Lubkin and Y. L. Luke, Frequencies of longitudinal vibration for a slender rod of variable section

The following typographical errors appeared in the above review:

(a) Line 3 of the review should read

$$\ldots \text{for } L_1 \leq x \leq L_1 + L_2 \ldots$$

(b) Formula in second line after frequency equation should read

$$\ldots \text{for } (L_1/L_2)/(1 + L_1/L_2) =$$

(c) The next line (3rd after frequency equation) should read

$$\ldots \text{and } [A(L_1 + L_2) - A(0)]\,/A(0) = -1(1/3)1$$

Ed.

Concerning AMR 6, 1859 (June 1953): A. Kuhelj, Contribution to the theory of elasticity of shells

The purpose of my paper was to show in an independent manner that Love's expressions for strain components in a shell are correct, although some doubts were raised against them (W. R. Osgood and J. A. Joseph, AMR **4**, Rev 1509). It follows from my results that generally accepted expressions for some of the components of the rate of rotation are not consistent with original suppositions and they must be changed. The last part of the above paper shows that many terms can be omitted in an engineering treatment of thin shells and that the resulting equations for cylindrical shells simplify the numerical work considerably. A. Kuhelj, Yugoslavia

Concerning AMR 6, Rev. 2749 (September 1953)

The author's name should be listed as Gerard, G.

Theoretical and Experimental Methods

(See also Revs. 3641, 3650, 3665, 3682, 3785, 3791, 3818, 3819, 3858, 3884, 3909, 3927, 3938)

3622. Timoshenko, S. P., History of strength of materials, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1953, x + 452 pp. $10.

This informal book is written for engineering students who have had a first course in strength of materials and in structures. It is planned to stimulate the student's imagination and interest by recounting briefly in intermixed form the history of the subject and the lives of many of the great men associated with its development. Fascinating bits of information are scattered throughout the book. For example, Professor Timoshenko mentions that a room capable of containing 2000 students was used for Galileo's lectures, and he also shows a picture of the living room of Galileo's villa. The reader is impressed over and over again with the early age at which most of the great figures began contributing to science and with the interchange of knowledge between countries.

Although both the theory of elasticity and the theory of structures are discussed in considerable detail, only those portions are included which Professor Timoshenko considers relevant to strength of materials today. Presentation of results in a manner clear and directly useful to the engineer is repeatedly praised and its absence strongly decried. This probably accounts for the omission of names such as Volterra and Somagliana and makes the chapters on the history of elasticity appear unbalanced when taken out of context.

Unfortunately, also, the reader cannot learn from the most careful reading of the book that, directly or indirectly, most of

the present work in all branches of applied mechanics in the United States is due to the teaching of Professor Timoshenko. So many people and institutions are included, however, that a listing would far exceed available space, and the coverage of topics is broad enough to include retaining walls, suspension bridges, and ships, as well as mechanics and testing of materials.

D. C. Drucker, USA

3623. Bellin, A. I., Non-autonomous systems, Advances in appl. Mech. III, 295–320, 1953. [Academic Press, Inc., N. Y.]

A survey is given of recent methods for the study of nonlinear, nonautonomous differential equations of second order $\ddot{x} = F(x, \dot{x}, t)$. If $F(x, \dot{x}, t)$ is periodic in t, considerable insight into the solution can be gained by determining certain gross characteristics in the phase plane, even if $F(x, \dot{x}, t)$ is severely nonlinear. This can be done with topological arguments, resulting in important conclusions about the stability of periodic solutions. Systems of class D, defined by Levinson and having the property $\limsup_{t\to\infty} x^2(t) + \dot{x}^2(t) < R^2$, are studied in some detail. These systems are dissipative for large displacements and large velocities and occur in many problems in engineering and physics. The analysis is applied to the severely nonlinear equations $\ddot{x} + f(x) = Fg(\sin \omega t)$, $\ddot{x} + a^2 x = \phi(x, \dot{x}, k, \epsilon, t)$, and $\ddot{x} + k\dot{x} + \omega^2 x(1 + \alpha x) = 3v \cos 2t$.

H. G. Loos, USA

3624. Martin, M. H., A generalization of the method of separation of variables, *J. rational Mech. Anal.* **2, 2,** 315–327, 1953.

Author first shows that elements of two subsets, $M(x)$ and $N(y)$, satisfy $\Sigma_{\alpha=1}^{n} x_\alpha y_\alpha \equiv 0$ for all $x \in M$, $y \in N$, if and only if $M \subset S_p$, $N \subset T_q$, where S_p and T_q are orthogonal linear subspaces of respective dimensions p, q, with $p + q = n$. He then sets the problem of finding solutions of the two-dimensional Laplace equation $\nabla^2 u = 0$ of the general form $u = u[X(x)\ Y(y)]$, or what is the same thing, of the form $u = u[X(x) + Y(y)] = u(U)$. He shows next that X and Y must satisfy $\Sigma_{\alpha=1}^{i} x_\alpha y_\alpha \equiv 0$, where $x_i(x)$ is a function of derivatives of $X(x)$, and $y_i(y)$ contains derivatives of $Y(y)$. But then x_α and y_α must be contained in orthogonal subspaces of E_i, and this property is used to derive all possible combinations of $X(x)$, $Y(y)$, and $u(U)$, and hence to find all solutions of the desired form.

R. E. Gaskell, USA

3625. Lappo-Danilevsky, J. A., Systems of linear differential equations [Systèmes des équations différentielles linéaires], vols. I, II, III (bound as one vol.), New York, Chelsea Publ. Co., 1953, xiv + 253 pp.; 208 pp.; 204 pp. $10.

The three volumes under review consist, for the most part, of the scientific material on systems of linear differential equations left by the author after his death in 1931. The task of preparing this material for publication was carried out by Professor V. Smirnoff and his collaborators, N. Kotchine and V. Krilov.

In the first volume, the author develops the general theory of functions of matrixes. Starting with fundamental definitions, there are considered, in succession, analytic functions of a variable matrix, of several variable matrixes, and of a denumerable set of matrixes. The volume ends with the algorithmic solution of the regular problem of Poincaré and the study of a system of linear differential equations in the neighborhood of an irregular singular point.

The second volume consists of four memoirs devoted to differential substitutions, the theory of matrixes satisfying systems of differential equations with arbitrary rational coefficients, the construction of a monodromy group of a system of linear differential equations with arbitrary rational coefficients, and the analytic continuation of series of compositions.

The third and last volume treats of integral equations, the problem of Riemann for Gauss's system, the algorithmic solution of Riemann's problem, and several additions to the theory of regular systems.

Systems of linear differential equations have always played an important rolé in the solution of significant physical problems. The theory of such systems is treated with elegance and generality by the author, and his contributions constitute an important addition to the field of differential equations.

E. J. Scott, USA

3626. Johnson, W. E., Analysis of stiff equations, Univ. Wisc., Nav. Res. Lab., CM-777, 27 pp., Feb. 1953.

In this paper, a class of first-order differential equations, known as stiff equations, is investigated mathematically. The solutions are characterized with regard to their qualitative behavior for large values of the independent variable. They fall into three distinct classes. Some of the results lead to numerical schemes that may be of practical use for computing a certain solution which varies slowly in a relative sense.

From author's summary

3627. Nitsche, J., On discontinuities of the derivatives of solutions of quasi-linear systems of hyperbolic differential equations (in German), *J. rational Mech. Anal.* **2, 2,** 291–297, 1953.

Discontinuities are propagated along characteristics in the case of nonlinear as well as in that of linear differential equations; whereas, however, in the latter case, the discontinuities must satisfy an ordinary differential equation from which it follows that these discontinuities cannot vanish along a characteristic; a Riccati equation may occur in nonlinear problems. It is concluded that infinite values for the discontinuities (jump intensities) may be expected at certain points of the characteristics of nonlinear differential equations.

These general results are applied to the equations of plane and rotationally symmetric stationary isentropic irrotational supersonic flow.

W. Freiberger, Australia

3628. Koenig, J. F., On the zeros of polynomials and the degree of stability of linear systems, *J. appl. Phys.* **24,** 4, 476–482, Apr. 1953.

Paper gives theorems relating to location of zeros of real or complex polynomials in any sector of the complex plane. Results are based on Routh-Hurwitz and allied theorems. Thus, given the characteristic equation of a linear physical system, results give rise to techniques for adjusting coefficients of equation so that its roots guarantee stable motion.

Y. L. Luke, USA

3629. Williams, E. J., and Kloot, N. H., Interpolation in a series of correlated observations, *Austral. J. appl. Sci.* 4, 1, 1–17, Mar. 1953.

Three formulas are derived for estimating the values of unmeasured members of a series when alternate values are known. Method is applied to an investigation of variation of density and of crushing strength in short strips cut from a certain kind of maple wood. Reviewer believes that engineers would prefer graphical interpolation methods.

S. Kolupaila, USA

3630. Temple, G., Theory of generalized convergence and generalized functions and its applications in mathematical physics (in French), *R. C. Mat. appl.* (5) **11,** 1–2, 1952 = *Cons. nat. Ric.* no. 356, 12 pp. 1953.

The object of this memoir is to express the theory of distributions invented by Laurent Schwartz in terms of two new notions—that of generalized convergence, and that of generalized func-

tions—with the goal of facilitating its applications to mathematical physics. The new theory [is] applied to certain typical techniques of mathematical physics: To the theory of the "finite part" of a divergent integral and to the theory of the Fourier integral. It [is] employed also to obtain the fundamental theorems of potential theory and of the theory of linearized, supersonic [flow]. From author's summary by M. Shinbrot, USA

3631. Gelfand, I. M., Lectures on linear algebra [Lektsii po lineinoi algebre], 2nd ed., Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1951, 252 pp.

Author's lectures at Russian universities form the basis of this excellent book containing 4 chapters and 2 appendixes. Methods of linear algebra become more and more important not only in pure mathematics but also in various branches of technical science (variational principles of mechanics, electricity, boundary-value problems, etc.), and Gelfand's book gives an excellent introduction to this objective. Although perfectly rigorous from a mathematical point of view, volume is presented so as to make its reading easy for engineers.

The first chapter constitutes an accurate foundation of the theory of n-dimensional affine and Euclidean spaces. Linear, bilinear, and quadratic forms present a fine and valuable application of foregoing abstract theorems and deductions.

The second main part is of special importance in applied mathematics and engineering, giving a careful treatment of linear transformations. Here, an engineer can find complete information about such fundamental questions as characteristic vectors, eigenvalues and their extremal properties, etc. The following section explains the useful concept of canonic form of a linear transformation and, beyond this, theory of λ-matrixes.

Fourth chapter presents elements of such profound questions as polylinear functions, general concept of tensor in abstract spaces, etc.

The engineer's attention is also called to appendixes containing some important numerical methods of linear algebra (e.g., evaluation of characteristic polynomials, computation of eigenvalues by iteration, elements of the disturbance method, and others).

The volume is highly recommended to mathematicians, physicists, and computing engineers. V. Vodička, Czechoslovakia

3632. Ludeke, C. A., and Morrison, C. L., Analog computer elements for solving nonlinear differential equations, *J. appl. Phys.* **24,** 3, 243–248, Mar. 1953.

The computer described here consists of electromagnetic coils which produce a sinusoidal motion, a cam-driven potentiometer, and a photoelectric arrangement to introduce nonlinearities. Cams for the potentiometer and masks for the phototube shutter must be cut to fit each nonlinear problem. The system seems capable of solving equations of the type $\ddot{\theta} + a\dot{\theta} + f(t)\,\phi\,(\theta) = 0$, provided θ is monotonic and f and ϕ are smooth enough for the physical limitations of the system. The paper does not state these limitations, nor the reasons for preferring the devices chosen to others that would represent the same type of equation. It shows diagrams of several special cases that have been solved, and states that several such devices can be connected to solve systems of simultaneous differential equations.

F. L. Alt, USA

3633. Davis, P., Errors of numerical approximation for analytic functions, *J. rational Mech. Anal.* **2,** 2, 303–313, 1953.

The error due to the use of many formulas of approximation may be regarded as linear functionals. By the use of the Riesz representation of bounded linear functionals and the utilization of Hilbert spaces of analytic functions of one and two variables, a general method of wide applicability is deduced which provides a "best possible" estimate of error in terms of a norm of the function to which the numerical process is being applied and a norm of the given linear functional. Methods are given for the calculation or estimation of both the function and functional norms. In addition, the functional norms for several types of numerical integration, a Lagrange interpolation formula, and the five- and nine-point rules for approximation of the Laplacian are computed. The method is of both theoretical interest and practical utility.

C. Saltzer, USA

3634. Tollmien, W., Remarks on error estimation for the Adams interpolation method (in German), *Z.A.M.M.* **33,** 4, 151–155, Apr. 1953.

Note outlines a correction to author's earlier paper [title source, **18,** 83–90, 1938]. Method takes into account the fact that partially overlapping interpolation polynomials which have the same function values and same first derivatives at the common station points may have different second derivatives at these same points. Practical application and comparison with other error bounds are deferred to another occasion.

S. H. Crandall, USA

3635. Thomas, T. S. E., Physical formulae, London, Methuen & Co., Ltd.; New York, John Wiley & Sons, Inc., 1953, vii + 118 pp., 7 diagrams. $2.

This collection of formulas of classical physics is, according to the preface, intended for the student and the worker in physics and engineering. The contents are divided into 10 chapters: I. Mathematics and statistics; II. Mechanics; III. Hydraulics (Hydrostatics and hydrodynamics); IV. Elasticity; V. General physics; VI. Acoustics and Fourier Series; VII. Heat; VIII. Light; IX. Electricity and magnetism; X. Electronics.

The formulas are, in general, well selected, and the booklet will prove advantageous for the student. However, reviewer is skeptical of its usefulness for the practical worker in physics and engineering because of the limited number of formulas, the lack of graphical representations, and the absence of numerical data. A few references to more extensive handbooks and textbooks at the end of each section would have increased the usability.

As to reliability, reviewer checked chap. VI in detail and found one formula incorrectly stated (formula for Helmholtz resonator applies for the long and not, as stated, for the short neck). Spot checks in other chapters revealed some insignificant misprints.

H. L. Oestreicher, USA

3636. Ten-place tables of logarithms of complex numbers and of the transformation from Cartesian to polar coordinates. Tables of the functions ln x, arctg x, $\frac{1}{2}\ln(1+x^2)$, $(1+x^2)^{1/2}$ [Desyatiznachníe tablıtsí logarifmov kompleksníkh chisel i perehoda ot dekartovíkh koordinat k polyarním. Tablitsí funktsii ln x, arctg x, $\frac{1}{2}\ln(1+x^2)$, $(1+x^2)^{1/2}$], Moscow, Izdat. Akad. Nauk SSSR, 1952, 116 pp., 1 plate. 10.80 rubles.

These tables contain ln x, for $x = 0(0.001)10$, and $\frac{1}{2}\ln(1+x^2)$, arctan x, and $(1+x^2)^{1/2}$, for $x = 0(0.001)1$, all with ten decimal places. Both first and second differences are listed. An insert contains $\frac{1}{2}x(1-x)$ for $x = 0(0.001)1$, 4D for use in quadratic interpolation, as well as $\ln 10^n$, $n = 1(1)25$, 12D.

Courtesy of Mathematical Reviews

3637. Pipes, L. A., An operational analysis of traffic dynamics, *J. appl. Mech.* **24,** 3, 274–281, Mar. 1953.

Equations of motion for line of n vehicles, whose movements are governed by simple postulated "law of separation," are set up and solved by Laplace transform theory for various simple pre-

scribed initial conditions and motions of leading vehicle. Mention is made of convenience of electrical analog computer for this study. L. Becker, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 3651, 3653, 3654, 3720, 3721, 3827, 3836, 3837)

3638. Ziegler, H., Linear elastic stability, *ZAMP* **4, 2, 3;** 89–121, 167–184, 1953.

The paper is a bold attempt to give a critical analysis and classification of mechanical stability problems. The author treats motion of rigid bodies as well as stability of elastic rods. Discussion is restricted, in general, to linear, holonomic, scleronomic systems. There is a contrast between gyroscopic and nongyroscopic systems. Special attention is given to critical angular velocity of rotating shaft.

The influence of damping is discussed in a section resulting in three theorems. The nonconservative systems are characterized by dissipative, circulatory, and nonstationary forces.

Throughout the paper, the criteria for stability are given in an extensive set of theorems. The motivation for this work is the inconsistency found in some recent attempts at the determination of stability conditions for apparently simple nonconservative systems. Criticism is expressed for the uncritical application of the equilibrium method of Euler and the energy method of Timoshenko to determine elastic stability. Author notes that these methods have attained such exclusive use that the concept of stability in elasticity has acquired a purely static meaning which sometimes results in errors.

The reviewer is of the opinion that the paper represents a very desirable move to critically examine the fundamentals of stability theory. It is unfortunate that specific treatment was lacking for the dynamic buckling of such elements as the column, involving in particular the elastic wave nature intrinsic to such problems.

W. H. Hoppmann, II, USA

3639. McKinsey, J. C. C., Sugar, A. C., and Suppes, P., Axiomatic foundations of classical particle mechanics, *J. rational Mech. Anal.* **2, 2,** 253–272, 1953.

Authors formulate a system of classical mechanics based on five primitive notions and six axioms. Using the latter, a number of theorems are proved which afford evidence that the axioms given are adequate for particle mechanics. Because theorems stated in the subjunctive mood as contrary-to-fact conditionals have been shown to be unsatisfactory, it is shown how one of the theorems can be formulated without the use of the subjunctive mood. The independence of primitive notions is also demonstrated.

It seems to the reviewer that if the axiomatized system of classical particle mechanics is to give results corresponding closely to physical reality, then the axiom of impenetrability must play an important role and cannot be thrust aside because it complicates proofs. It appears, too, that what initial flexibility is gained by considering the individual forces on the particle, rather than the resultant of these forces, is lost by making the proofs in the sequel somewhat more involved.

The problem of formulating a satisfactory axiomatic treatment of particle as well as general mechanics is an important one and this paper makes a noteworthy attempt to solve the first of these problems. E. J. Scott, USA

3640. McKinsey, J. C. C., and Suppes, P., Transformations of systems of classical particle mechanics, *J. rational Mech. Anal.* **2, 2,** 273–289, 1953.

This paper is a companion to the preceding review and attempts to place particle mechanics on an axiomatic basis, using the languages of modern algebra and logic. Six assumptions are made, namely: (a) The number of particles in a system is finite; (b) time is represented as a number; (c) second time derivatives of position vectors exist; (d) masses are positive real numbers; (e) the vector sum of all forces acting on a particle is absolutely convergent; and (f) force equals mass times acceleration. Definition 5 in this paper defines what is called an "ultraclassical" system. In simple language, the definition says that the force on the i-th particle due to the j-th is equal and opposite to that of the j-th particle due to the i-th; furthermore, the magnitudes of these forces are a function only of the separation of the particles.

The present paper by McKinsey and Suppes concerns four theorems on transformations permitted in particle mechanics. The first theorem says in effect that (a) the unit and origin of time can be changed in a linear fashion; (b) mass can be scaled linearly; (c) a position vector can be transformed by a series of rotations about the origin, reflections, and stretches followed by a shift in the origin and the impositions on the coordinate system of a uniform velocity; and (d) forces suffer the same rotations and reflections as the position vectors plus stretches proportional to those imposed on the position vectors. Theorem 3 says these are the only transformations permitted. Theorem 2 says that transformations restricted to equal stretches along all axes will preserve the ultraclassical characteristics of a system, while Theorem 4 is the converse of 2; namely, that the ultraclassical character is preserved only with this type of a transformation.

H. M. Trent, USA

3641. Zhukovskiĭ, N. E., Theoretical mechanics [Teoreticheskaya mekhanika], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1952, 811 pp.

Book contains lectures read at the University of Moscow from 1886 to 1920. Clarity of exposition, fullness and completeness of derivations, and geometrical and physical interpretation of mathematical terms characterize the volume. Subjects treated are kinematics, geometrical statics, dynamics of a particle, analytical statics, dynamics of systems, hydrostatics, hydrodynamics, and theory of attraction.

Under kinematics are discussed motion, velocity, acceleration, composition of velocities, and composition of accelerations as applied to a particle and rigid systems.

Under geometrical statics is found discussion of fundamental laws of mechanics, composition of forces, moment of force center of gravity, theory of couples, and equilibrium.

Next we find dynamics of a free particle and fundamental theorems of mechanics for a free and restrained particle. Kinetic energy and force function are also considered. Problems investigated range from elementary to the highest orders.

Analytic statics is concerned with external and internal forces, dynamic and geometric systems. Mechanical systems, the material particles of which are held by mutual forces and free to move in any direction, are called dynamic systems. If the particles of a system are not free to move in all possible directions, such systems are called geometrical. In this part of the book, the theory of virtual displacements is fully treated. Virtual displacements are used in subsequent investigations.

In dynamics of systems, author introduces d'Alembert's principle, differential equations of motion, motion of dynamical systems, fundamental theorems of dynamics, Lagrangian equations of motion, Hamilton's equations, and principle of least action. Theory of gyroscopes and impact receive attention here.

The principles of hydrostatics are set down in a rigorous manner. Fluids are treated as dynamical and as geometrical systems. Stability of floating bodies completes this part of the

book. Next, the principles of hydrodynamics are expounded. Eulerian and Lagrangian equations, steady state, and velocity potential are discussed. Theorems of Bernoulli, Lagrange, and Helmholtz conclude the exposition on hydrodynamics.

In the last part of the book, we find general formulas of theory of attraction and potential function with various applications. The concluding articles treat of the general theory of the potential. S. Sergev, USA

3642. **Nadile, A., Dynamic problems of nonholonomic systems possessing a kinetic potential** (in Italian), *Atti Sem. Mat. Fis. Univ. Modena* **5**, 66–82, 1950–1951.

Author starts with Hamel's equations for anholonomic systems under conservative forces. Such equations contain kinetic characteristics ω_h and kinetic energy T as a function of them.

Movement equations are considered equivalent to variational conditions, and it is shown that equivalence holds also when kinetic potential $\mathfrak{L}$ is an arbitrary function of generalized coordinates q_i and kinetic characteristics ω_h. Particular case is proposed in which generalized forces Q_i linearly depend on those characteristics. Conditions are derived for existence of kinetic potential.

Paper finally considers reduction of movement equations to canonical form. Necessary and sufficient condition is that equation

$$\pi_i = \partial\mathfrak{L}/\partial\omega_i$$

be solvable in terms of the ω_h's.

J. E. Carrizo Rueda, Argentina

3643. **Nadile, A., Synthetic representation of the equations of motion of nonholonomic systems** (in Italian), *Atti Sem. Mat. Fis. Univ. Modena* **5**, 126–145, 1950–1951.

Author observes that anholonomic-systems equations avoid direct application of common analytic methods, owing to their complicated formulation. Simplification is obtained by introduction of mathematical spaces with a metric in terms of kinetic energy

$$dQ^2 = 2Tdt^2 = \sum_1^n a_{rs}dq_r dq_s$$

Movement equations are reduced to the very simple form

$$(d^2Q/dt^2 - \text{grad } U) \times B_{m+h} = 0$$

in which the B's are vectors, tangent to that space, and vector parenthesis is Boggio's general expression for holonomic systems. Author derives from his own equation another one without acceleration term but with the kinetic characteristics and their temporal derivatives. Particular cases are presented but they appear in a very condensed form. Some applications would make this paper highly didactic.

J. E. Carrizo Rueda, Argentina

3644. Fleischel, G., Efficiency charts for planetary gears (Les rendements planétaires en diagrammes), Paris, Dunod, 1953, 40 pp. + 10 figs.

Charts give quick estimates of efficiency for wide range of cases, including both fixed and moving "controlled" element. To use charts it is necessary to first estimate "basic efficiency" (efficiency of ordinary train formed by holding the planet carrier stationary). It is assumed that power loss in planetary train is equal to percentage of loss in ordinary train multiplied by "power" calculated using speed of gears relative to planet carrier.

Numerous examples clarify use of charts and add to reader's understanding of possibilities and limitations of planetary trains.

A. S. Hall, USA

3645. Conference on gears 1950 [Fachtagung Zahnradforschung], Braunschweig, Friedr. Vieweg & Sohn; Schriftenreihe Antriebstechn. H. 1, 195 pp. DM 11.80.

Book gives the proceedings of the technical session on various aspects of gear technology; papers (except three published elsewhere) and discussions are reprinted in full. First paper (G. Niemann, "Present status of gear research") gives introduction to the session and lists and discusses primary areas of gear research requiring attention.

Second paper (C. Weber, "Mathematical problems of gear research") discusses tooth pressure and its distribution, considering effects of Hertz contact forces, tooth and gear body deflections, and lubricant film pressures.

Third, fourth, and fifth papers (G. Niemann and H. Glaubitz, "Tooth base strength of straight spur steel gears"; "Tooth surface strength of straight spur steel gears"; "Helical gearing: Influence of helix angle on heating, wear, surface strength, and noise for narrow gears") are published in *VDI-Zeitschrift* **92**, 1950, **93**, 1951, and only discussions are reported.

Sixth paper (H. M. Hiersig, "Increase of load-carrying capacity of spur gear transmissions through use of optimum tooth profiles") discusses the kinematic and strength aspects of modified tooth forms, with emphasis on standardization and interchangeability.

Seventh paper (H. Glaubitz, "Materials and heat treatments for hardened gear teeth, users' requirements") discusses the depth and shape of hardened cases and soft cores and the resulting performance characteristics.

Eighth paper (H. M. Meingast, "Materials and heat treatments for hardened gear teeth, manufacturing feasibility") discusses various methods of tooth-hardening, their relation to the tooth material, appropriate temperature-time relations, and comparisons of various possible methods in terms of materials and desired surface strength.

Ninth paper (G. v. Oehsen, "Experience with induction and flame hardening") discusses a machine for induction hardening of gears used for a streetcar electric motor drive.

Tenth paper (K. Bürger, "Measurement of gear tooth errors due to heat treatment") discusses the individual errors commonly resulting from heat treatment, and instruments and methods for measuring them.

Eleventh paper (G. Apitz, "Construction of interchangeable straight and curved tooth bevel gears") discusses the theory, methods of manufacture, and measurement and checking of subject gears.

Twelfth paper (A. Cameron, "On the theory of gear-tooth lubrication") reports on experimental study, using the Merritt two-roller machine, of gear-tooth lubrication, to find support for (1) the great (compared to theory) film load-carrying capacity, and (2) the independence between the effective coefficient of friction and tooth load.

Thirteenth paper (H. Block, "Transmission lubricant, a design component") discusses the load-carrying and thermal properties of lubricants, with emphasis on the fact that the lubricant must be designed as part of the drive.

Fourteenth paper (D. B. Welbourn, "Remarks on the true values of tooth strength of transmissions") reports an experimental dynamic load study, using a planetary drive.

Fifteenth paper (K. Ross, "Methods for non-cutting manufacture of gear teeth—cold-forming") gives a brief account of cold rolling of gear teeth, listing strength characteristics, accuracies, and production times. G. A. Nothmann, USA

3646. Bastow, D., Independent rear suspension, *Instn. mech. Engrs. Auto. Div. Proc.*, part II, 35–44, 1951–1952.

The improvements which can be derived from independent rear

suspension (I.R.S.) are discussed under the headings of unsprung weight, propeller-shaft torque effect, elimination of rear-axle misbehaviors, sideways movement of rear of car due to one-wheel bump, and better utilization of space at rear of car. The requirements for I.R.S. are given as acceptable handling characteristics, favorable cost comparison with accepted rear-axle layouts, mechanical reliability and simplicity. It is shown that oversteer need not occur. Comparisons are made with the behavior of cars equipped with the DeDion-type axle. Reference is made to a classification of the different types of I.R.S. by Wolfe.

Marshall Holt, USA

3647. Lawden, D. F., Escape to infinity from circular orbits, *J. Brit. Interplanetary Soc.* **12**, 2, 68–71, Mar. 1953.

The problem of fuel economy in escape from a circular orbit to infinity is discussed. It proves to be more economical to escape directly via a single tangential impulse applied in the circular orbit, unless the velocity desired after escape has been effected is more than the escape velocity for a body stationary at any point of the circular orbit. Also, the relative position between the initial orbit and the final orbit is discussed. L.-W. Hu, USA

3648. Schaub, W., Tidal forces acting on space stations (in German), *Weltraumfahrt* no. 1, 1–8, Jan. 1952.

The generation of tidal phenomena is first discussed generally. It is shown that the tidal forces on a rigid satellite will exceed its own gravitation below a minimum distance from the central body. Objects which are loose on the surface of the satellite will, accordingly, tend to move off into space. A deformable satellite at about twice that minimum distance may break up; the tidal forces at that distance can exceed its cohesion. This is stated to have been the cause of the destruction of a satellite of Saturn and the origin of its ring. These effects should, it is pointed out, be carefully considered in any plans for the assembly on the spot of a space station. R. Drenick, USA

Gyroscopics, Governors, Servos

3649. Wass, C. A. A., and Hayman, E. G., An approximate method of deriving the transient response of a linear system from the frequency response, *Aero. Res. Counc. Lond. curr. Pap.* 113, 13 pp., 7 figs., 1953.

A method based on the response of a linear system to a square wave input which can be represented by a Fourier series is used to obtain transient response from the frequency response. The half-period of the square wave is assumed sufficiently long so that the system output has settled to a stationary value before the input changes to its other stationary value (not too lightly damped systems). The selection of the optimum square wave frequency for any system is based on familiarity with the procedure.

An example shows that consideration of responses up to the eleventh harmonic gives transient response curves which are in error by less than 2% as compared with the exact solution. Tables and a circular computer are given to speed calculations.

This method is more rapid than other known methods but less accurate. H. G. Lew, USA

3650. Fossier, M. W., and Rosen, H. A., A field-mapping method for analysis and synthesis of linear closed-loop systems, *J. aero. Sci.* **20**, 3, 205–209, Mar. 1953.

A field-mapping method that is an extension of the usual steady-state transfer function methods of analyzing closed-loop systems is presented. It is shown that, for such a system, the open-loop transfer function may be represented as a potential flow field in the complex plane, and the flow field in the vicinity of closed-loop roots may be determined graphically by means of analytic continuation. The method allows a quick determination of the closed-loop roots for any value of loop gain and, further, shows the dependency of the roots on additionally introduced phase shifts. From authors' summary by L. B. Hedge, USA

3651. Frenkel, M. S., Formulation of "stability equations" and the derivation of new constructions, with complete systems of design-formulae, for variable-speed control mechanism, Instn. mech. Engrs., 15 pp., Mar. 1953.

Paper deals with stability analysis of velocity sensitive controller such as a fly-ball governor. Theory is treated from a completely general point of view. Relationships between sleeve force, speed, and spring force are set up as power series, thus permitting arbitrary nonlinear functional relationships. Techniques are established whereby desired stability characteristics may be first established; from these the necessary functional relationships between sleeve force, speed, and spring force may be determined so that straight kinematic procedures may be applied to establish an actual design.

The process is distinctly complicated for routine design work but may be of value in certain highly technical developments.

C. D. Pengelley, USA

3652. Golden, P. L., and Headrick, A. G., A sensitive pressure controller for high-pressure service, *Trans. ASME* **75**, 3, p. 329, Apr. 1953.

An automatic, sensitive, pneumatic pressure controller has been developed for regulating the flow of hydrogen to a bench-scale, high-pressure, hydrogenation unit. It utilizes a 20-turn helical Bourdon tube which is connected to the flapper of a nozzle-flapper combination. When the nozzle is closed, air pressure in the controller acts through a system of bellows and cylinders on a rack which drives a gear connected to the regulating valve. The controller prevents slow drifts of pressure and has operated satisfactorily at 9000-psig pressure.

From authors' summary

3653. Arnold, R. N., and Maunder, L., The motion due to slow precession of a gyroscope driven and supported by a Hooke's joint, *Instn. mech. Engrs. Proc. (B)* **1B**, 3, 77–89, 1952.

Motions and equilibrium positions of rotor axis of unconventional gyroscopic system subjected to uniform precession about axis normal to driving axis are found experimentally for several values of the various system parameters. System dynamics are approximately analyzed and solutions for rotor equilibrium positions are indicated. Fair agreement is obtained between experimental and analytical results. It is shown that above motions consist of spiral paths culminating in the equilibrium positions. L. Becker, USA

Vibrations, Balancing

(See also Revs. 3665, 3703, 3720, 3721)

3654. Föppl, O., The steady state of vibration of a mass point m under the influence of a periodic force p (in German), *Schweiz. Arch.* **19**, 1, 6–14, Jan. 1953.

The analysis consists of referring the relation between force and acceleration to each unit of a moving system. After combining the units, a steady state of motion is obtained in which the combined forces are derived from the combined velocities. The analysis is especially instructive in considering a simple vibration.

Author states that, contrary to his and to A. Föppl's previous publications [O. Föppl, "Technische Schwingunslehre," 1931; A. Föppl, "Vorlesungen" IV], the vibration of a spring fixed at one end with a mass at the other end is not the simplest case. It is actually a complicated combination of two states of vibration, the build-up and the damping. Both are not dependent on each other. Assuming a periodic force acting axially on the mass at the end of the spring and a damping force which is proportional to the first or second power of the velocity (air, for instance), then a steady state of vibration is only possible at a definite single amplitude and the corresponding velocity at the zero position. The smallest deviation from this amplitude will upset the steady state and cause the amplitude to become either infinite or zero. The internal work of the spring material is sufficient to destroy the equilibrium of the steady state. The simplest case is the assumption of a damping force equal and opposite to the periodic exciting force. Author applies a periodic force with components in line with the axis of the spring and perpendicular to it. The steady state of vibration of a spring fixed at one end with a mass at the other end and acted upon in such a manner is obtained by analyzing, first, the build-up of the vibration from the state of rest; second, the damping of the vibration; and then by combining synthetically both conditions. The result is a cycloidal motion of the mass. F. B. Schneider, USA

3655. **Dam, D., Vibration measurement techniques and their application for the balancing of rotating machines** (in German), *Bull. Assn. suisse Elect.* **44**, 1, 4–11, Jan. 1953.

Linear vibration theory of one degree of freedom is reviewed and the principles of electrodynamic (lines of force cut by relative motion of coil and magnet) and electromagnetic (variable inductance) pickups are outlined. Variable-coupling and variable-resistance units for vibration detection are described and the accompanying electrical circuits are sketched. Use of information from these devices in balancing rotating machinery is discussed briefly. G. Murphy, USA

3656. **Jewell, W. R., Apparatus for measuring internal friction in transversely vibrating metal reeds,** *Rev. sci. Instrum.* **24**, 1, 7–10, Jan. 1953.

Paper describes apparatus for measuring internal friction of ferromagnetic reeds set in transverse vibration. It includes a description of a symmetrical transducer for inducing the vibrations and an optical method of observing the amplitude. Measurements can be made while the reed is temperature controlled and vibrating in a vacuum. From author's summary

3657. **Lee, Y. C., Gore, M. R., and Ross, C. C., Stability and control of liquid propellant rocket systems,** *J. Amer. Rocket Soc.* 23, 2, 75–81, Mar.-Apr. 1953.

The Summerfield theory for the low frequency or chugging instability of a monopropellant rocket system [title source, **21**, 5, 108–114, Sept. 1951], which assumes a constant combustion time lag, is extended to a bipropellant system. Stability boundary curves are presented in static gain vs. time lag coordinates for a wide range of system parameters. The possibility of stabilizing the rocket system for arbitrary combustion time lag is demonstrated under the assumptions made in the analysis.
H. R. Lawrence, USA

3658. **Porter, F. P., Torsional vibration notes with solutions for an untuned viscous damper and flexible coupling with nonlinear elasticity,** *Trans. ASME* **75**, 2, 241–262, Feb. 1953.

Several special relations are derived that may be used to simplify the solution of certain phases of the torsional vibration problem. A solution is described for the vibration of a system with an untuned viscous damper. Numerical values are given for the nonlinear elasticity of the Falk-Bibby-type couplings. These values are rearranged into a form suitable for calculating undamped resonance curves of an engine installation which includes one of these couplings. An approximate solution for the resulting vibration is described and illustrated by calculation.
From author's summary by J. W. Cohen, Holland

3659. **Mindlin, R. D., Mason, W. P., Osmer, T. F., and Deresiewicz, H., Effects of an oscillating tangential force on the contact surfaces of elastic spheres,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 203–208, 1952.

Paper briefly reviews the work of Cattaneo and of Mindlin [AMR **3**, Rev. 2592], in which a tangential force system is superposed on the Hertz contact problem for elastic spheres, while holding the normal Hertz force N constant. The Cattaneo-Mindlin theory shows how to evaluate effects of slip on contact-surface tractions and displacements. Slip is found to occur, and penetrates radially inward from edge of contact surface, as tangential force T increases monotonically from zero up to some value T^* (less than the value for incipient motion). Present paper investigates case where T diminishes from T^* to smaller values (N always constant). Next studied is the oscillation of T between T^* and $-T^*$, forming a hysteresis loop of tangential load vs. tangential contact-surface displacement (theory shows latter is uniform for region to which slip has not penetrated).

Theory is tested by ingenious experiments in which a system of polished crown glass lenses are driven at low frequency by a barium-titanate transducer. Measurements of wear patterns on the contact surfaces yield good agreement with theory; measured force-displacement (hysteresis-loop) curves also agree, but more roughly. For small displacements, energy dissipation per cycle varies as square of displacement rather than as cube (theory predicts latter). For larger displacements, agreement is better.
J. L. Lubkin, USA

3660. **Pian, T. H. H., and Hallowell, F. C., Jr., Structural damping in a simple built-up beam,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 97–102, 1952.

Paper deals with damping in simple beam having screw-fastened reinforcing spar caps. Problem is simplified by considering slippage between cap and beam alone.

Nonlinear component of load-deflection curve is found to contain mainly a second-power term, and energy loss per cycle to vary approximately as third power of vibration amplitude. Test results agree with theory. A.-t. Yu, USA

3661. **Gross, W. A., and Soroka, W. W., Electrical analogy for dynamical systems containing broken-linear unsymmetrical elasticity,** Proc. First. U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 133–138, 1952.

Problem discussed here concerns method for studying nonlinear mechanical problems by electrical-circuit-analog means; it especially concerns nonlinearities introduced by preset springs, i.e., springs where the rate suddenly changes value at some prescribed value of deflection. Problem is of interest in the applied mechanics field, particularly among engineers concerned with vibration damping.

Method involves use of electrical-circuit analogs, as distinguished from more elaborate and expensive analog computers and differential analyzers. Such an analog is described, designed with relatively few inexpensive components. Experimental

method of analysis described is more feasible than a mathematical computation of response.

Besides providing specific results for the interesting but restrictive problem used in the example, paper suggests a useful general technique and contains practical suggestions regarding the design and use of such analogs.

Reviewer believes that while no new basic principles are introduced (principle of electric circuit analogs is contained in many textbooks, and electronic circuits used were proposed in references cited by paper), paper is nevertheless of value because it provides electronic design information in regard to such analogs and calls further attention to this important analysis tool.

R. Kochenburger, USA

3662. **Öz, I. H., Two methods for calculation of intake air vibrations,** *Bull. tech. Univ. Istanbul* **4,** 1, 90–101, 1951.

Paper gives an analytical investigation of air vibrations in intake manifolds of high-speed combustion engines. The vibration results from an induced rarefaction wave which travels to the end of the intake pipe with the velocity of sound, where it is reflected according to the boundary conditions at that point. The reflected wave adds to the wave created by the piston and thus disturbs the stationary intake procedure. The vibration is appreciable at high speeds and in long pipes.

Author gives two approximate solutions, the first of which neglects the velocity of flow in comparison with the velocity of sound. A second solution considers the velocity of flow and leads to a nonlinear differential equation which the author solves after making simplifying assumptions concerning the intake mechanism phenomenon. P. G. Jones, USA

Wave Motion, Impact

(See also Revs. 3789, 3878, 3937)

3663. **Burgers, J. M., Nonuniform propagation of plane shock waves,** "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 101–108, 1953.

Problems of nonuniform propagation of shocks are briefly treated by Lagrangian method. As an example, the case where the gas in front of the shock has constant temperature but where, due to gravity, the pressure and the density decrease exponentially in the direction of propagation is considered by infinite series method. Methods for obtaining approximate solutions are also discussed. For detailed information, the author's lecture [AMR **5,** Rev. 2102] should be consulted. Y. H. Kuo, USA

3664. **Bruniak, R., Structure of shock phenomena** (in German), *Öst. Ing.-Arch.* **7,** 2, 128–134, 1953.

The thickness of a steady normal shock wave is computed under the assumptions that the viscosity coefficient is constant and that the heat conductivity is zero. Simple integrations lead to a result which compares favorably with that computed by von Mises, who included the variability of viscosity and heat-conductivity coefficients. I. Flügge-Lotz, USA

3665. **Hall, L. H., Longitudinal vibrations of a vertical column by the method of Laplace transform,** *Amer. J. Phys.* **21,** 4, 287–292, Apr. 1953.

An interesting illustrative problem in mechanics is the motion executed by a vertical rod when it suffers loss of support at the bottom. A solution is presented by the method of Laplace transform in two alternative forms: One represents the motion as a superposition of free fall and two oppositely directed progressive waves equal in amplitude and form; the other, as a free fall and a pulse, initiated at the bottom and propagated up and down the column upon reflection at the ends.

From author's summary by F. I. Niordson, Sweden

3666. **Dengler, M., Goland, M., and Wickersham, P., Propagation of elastic impact stresses,** Midwest Research Inst., tech. Rep., xi + 33 pp., Oct. 1952.

Long steel beams of square cross section were subjected to transverse impact by steel spheres, and the resultant time histories of bending strain were measured at several spanwise stations; the history of impact force was determined by means of a barium-titanate force gage. Previous analytical work by Dengler and Goland [AMR **6,** Rev. 2703], based on Timoshenko's beam theory (which takes into account the first-order effects of transverse shear and rotary inertia), is used to obtain theoretical predictions for the bending strains; integral expressions for the strain due to an impulse loading are evaluated numerically, and Duhamel's integral is used to find the strains due to any given history of loading. The measured strain histories are found to follow the predicted ones very closely, but, in addition, they exhibit small-amplitude, high-frequency components not accounted for by the theory under consideration.

B. Budiansky, USA

3667. **Meyer, R. E., On waves of finite amplitude** in ducts, "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 41–45, 1953.

See AMR **6,** Rev. 1971.

3668. **Schmieden, C., The impact of bodies of revolution on water surfaces** (in German), *ZAMM* **33,** 4, 147–151, Apr. 1953.

In a previous paper [*Ing. Arch.* **10,** 1, 1939], the author extended the classical two-dimensional solution of the water-impact problem, given by H. Wagner in 1932, to the case of a solid of revolution of large radius of curvature, the results being given in the form of series. In the present paper, he shows that the solution can be expressed in the form of an Abel integral equation, and solutions are given in parametric form for the thrust at impact, the depth of immersion, and time. The special cases discussed are those of (a) the right circular cone, (b) the sphere, and (c) a body of revolution whose profile is a sine curve.

R. M. Davies, Wales

3669. **Liepmann, H. W., Roshko, A., and Dhawan, S., On reflection of shock waves from boundary layers,** *NACA Rep.* 1100, 29 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 3609.

3670. **Mayo, W. L., Hydrodynamic impact of a system with a single elastic mode. I—Theory and generalized solution with an application to an elastic airframe,** *NACA Rep.* 1074, 17 pp., 1952.

Supersedes article reviewed in AMR **1,** Rev. 703.

3671. **Miller, R. W., and Merten, K. F., Hydrodynamic impact of a system with a single elastic mode. II—Comparison of experimental force and response with theory,** *NACA Rep.* 1075, 7 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 3154.

3672. **Gibbons, J. J., and Schrag, R. L., A method of solving the wave equation in a region of rapidly varying complex refractive index,** *J. appl. Phys.* **23,** 10, 1139–1142, Oct. 1952.

A process is described whereby the complex wave equation is

transformed into an integrodifferential equation in a single real dependent variable. This makes possible a technique for obtaining wave functions, which is believed to offer definite advantages in some instances where the more standard methods are difficult to handle; e.g., in regions where the complex index is varying rapidly. The index may be entered in a tabulated form, and its exact analytical expression is not required.

The technique is then demonstrated by computing the reflection coefficient associated with an extremely critical region, that which one encounters at the "fourth reflection condition," where the refractive index goes through a sharp peak [S. K. Mitra, "The upper atmosphere," *Roy. Asiastic Soc. Bengal*, 1947].

From authors' summary by V. Kopřiva, Czechoslovakia

3673. **Stoneley, R., The transmission of Rayleigh waves across Eurasia,** *Bull. seism. Soc. Amer.* **43,** 2, 127–135, Apr. 1953.

An approximate treatment by Rayleigh's principle was made to study the problem of propagation of Rayleigh waves in a double surface layer. Accuracies of the method were discussed and thicknesses of so-called granitic, intermediate, and ultrabasic layers were computed, based on the group velocities of Rayleigh waves observed in earthquakes. "Reduced values" of thicknesses obtained in this way are consistent with those previously computed for Eurasia from Love waves. K. Kasahara, Japan

3674. **Ursell, F., Edge waves on a sloping beach,** *Proc. roy. Soc. Lond.* (*A*) **214,** 1116, 79–97, Aug. 1952.

This paper discusses the frequency spectrum of a canal closed at one end by a sloping beach. As well as a continuous spectrum, there are discrete resonant frequencies, the number of these depending on the angle of slope of the beach. These are the Stokes "edge waves" in which the amplitude decays exponentially with distance from the shore [Lamb, "Hydrodynamics," 1932, 6th ed., p. 477]. Author discusses amplitudes in the neighborhood of a resonance and considers the effect of viscosity on the results.

Model tank experiments are described and the main features observed are satisfactorily accounted for by the theory. The slope of the model beach is much larger than a real beach; for the model, the effect of viscosity will be larger, tending to suppress the sharpness of the resonance. Also, the number of discrete resonant frequencies corresponding to "edge waves" will be larger. This investigation will form the starting point for all further work in the subject. J. M. Jackson, Scotland

Elasticity Theory

(See also Revs. 3666, 3692, 3694, 3698, 3705, 3713, 3728, 3833)

3675. **Dörr, J., Analysis of several integrals, containing Bessel functions, which are of significance in the theory of elasticity** (in German), *ZAMP* **4,** 2, 122–127, 1953.

Several improper integrals, containing the square of a Bessel function of the first kind, are transformed into integrals, with finite limits, involving Struve functions of orders zero and unity. Purpose of this transformation is to make the integrals tractable by numerical methods. H. Deresiewicz, USA

3676. **Wenk, E., Jr., and Taylor, C. E., Analysis of stresses at the reinforced intersection of conical and cylindrical shells,** *David W. Taylor Mod. Basin Rep.* 826, 19 pp., Mar. 1953.

The evaluation of stresses and deformations in symmetrically loaded conical shells is a laborious procedure, involving the solution of several simultaneous equations containing a comparatively large number of Bessel functions. In dealing with the problem of the closed conical shell under pressure, attached at the larger diameter to a cylindrical shell or to a cylindrical reinforcing ring, the authors have developed a considerably shorter method of stress analysis that is closely approximate in most cases and gives satisfactory results for all but very flat or thick cones. This is accomplished by neglecting the second-order term in the fourth-order differential equation of elastic deflection and other approximations of a similar nature, thus reducing the number of Bessel functions in the resulting working equations. The method of analysis and the equations are given for solution of the problem specified in the title of the paper. In addition, formulas are given for edge rotation and displacement of the open end of the cone in terms of pressure and edge loading. These may be used in the solution of more general problems involving the attachment of a closed conical shell to other bodies. The authors compare results obtained by their method to the exact solutions by Dubois and find generally good agreement. E. G. Allen, USA

3677. **Faupel, J. H., and Furbeck, A. G., Influence of residual stress on behavior of thick-wall closed-end cylinders,** *Trans. ASME* **75,** 3, 345–354, Apr. 1953.

Authors investigated the behavior of heavy wall steel cylinders under internal pressure and found that macro-residual stresses introduced by heat treatment could have a significant effect on dilation characteristics. These residual stresses can be as high as the yield stress of the material and frequently act in the same direction as stresses induced by internal pressure.

Strain measurements were carried out by SR-4 resistance strain gages, and residual stresses for the various heat treatments were determined by successive removal of metal layers (Sachs method) and by recording the corresponding changes in strains. The results indicated that only the initial yielding at the bore was influenced by these residual stresses.

The authors develop a method of numerically accounting for macro-residual stresses when predicting the internal pressure at initial yielding at the bore. N. Sag, Australia

3678. **D'Appolonia, E., and Newmark, N. M., A method for the solution of the restrained cylinder under compression,** Proc. First U. S. nat. Congr. appl. Mech. June 1951; J. W. Edwards, Ann Arbor, Mich., 217–226, 1952.

The "lattice-analogy" method is extended for numerical solutions of radially symmetric elastic bodies. The lattice is built up of pin-connected bars and is set up in terms of displacements. As an illustrative example of the method, the solution of the end-restrained cylinder under compression is obtained. The agreement with the existing analytical solution [G. Pickett, *J. appl. Mech.*, Sept. 1944] is remarkably good. P. M. Naghdi, USA

3679. **Swainger, K. H., Doublet vector fields in elastic straining,** Eighth Inter. Congr. theor. appl. Mech., Istanbul, Aug. 1952, 4 pp.

This is a continuation of the author's series of papers on elasticity in which he obtains results in manifest contradiction to the classical theory. In the present paper he concludes that, in the small-strain, small-rotation theory, in addition to satisfying the compatibility equations, the pure strain must be a lamellar function. H. Deresiewicz, USA

3680. **Hershey, A. V., A review of the definitions of finite strain,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 473–478, 1952.

An elementary sphere in a deforming medium is transformed into an elementary ellipsoid. The principal components of the strain tensor may be defined as the increase in length per unit length along the principal radii of the ellipsoid; the principal

axes of the strain tensor may be defined as the principal axes of the ellipsoid. This conventional definition of strain has long been recognized in connection with homogeneous strain, but apparently has only recently been extended to the general case of strains of any type. Various published representations of strain are compared in the present paper with the conventional strain. The analysis is illustrated by an application to the practical case of a surface grid which is simultaneously stretched and sheared at variable rates.

From author's summary by W. T. Koiter, Holland

3681. Colonnetti, G., On the value of Poisson ratio in elastoplastic phenomena (in French), *C. R. Acad. Sci. Paris.* **235,** 23, 1460–1462, Dec. 10, 1952.

This note concerns some questions raised in a review of author's paper, "Elastoplastic equilibrium during passage of time" [AMR **5,** Rev. 1082] and in a Communication thereon [AMR **6,** Feb. 1953]. After having made it clear that the statement contained in that paper, to the effect that variations of plastic deformations are proportional to initial stresses, should be taken to mean that such variations are linear homogeneous functions of the initial stresses, author proceeds to discuss which value should be given to the Poisson ratio in the initial phase of the plastic process, when plastic deformations are very small, of the order of magnitude of elastic deformations. It is this phase that is considered in his studies, and it is the most interesting from the practical standpoint. No experimental results are available for this phase, but the difficulty of exactly defining the elastic limit (a definition that largely depends on the sensitivity of our instruments) seems to indicate that there is a continuous transition from perfect elasticity to perfect plasticity, with a continuous variation of the values of the physical constants, including the Poisson ratio. Hence, author deems it reasonable to assume that the Poisson ratio retains practically the elastic value in the phase of plasticity considered. He also concludes this in view of experimental results (Schaefer, Swainger) which show not only that the value of the Poisson ratio in the elastic range is by no means constant for different materials, but also that its value in the plastic range may be much less than the generally assumed 1/2. This assumption at least eliminates all the great mathematical complications which would be brought about by the introduction of different values for the Poisson ratio, when elastic and plastic deformations of the same order of magnitude are simultaneously present; and the assumption is, in the author's opinion, as much justified as the fundamental assumptions of the classical theory of elasticity. P. L. Romita, Italy

3682. Tiffen, R., Solution of two-dimensional elastic problems by conformal mapping on to a half-plane, *Quart. J. Mech. appl. Math.* **5,** part 3, 352–360, Sept. 1952.

Author considers the generalized plane stress of a plate whose middle plane is bounded by an unclosed curve. The method of A. C. Stevenson is used, the middle plane being mapped conformally into a half plane. The two complex potential functions which yield the stress, strain, and displacement are determined from integrals analogous to the Poisson integral, when the given edge load is either normal or tangential, and when the given edge displacement is either normal or tangential. Of course, superposition of these solutions permits treatment of more general problems. As an example, the case of a plate with a parabolic boundary is solved for some simple loadings.

G. E. Hay, USA

3683. Daniels, J. M., High power solenoids; stresses and stability, *Brit. J. appl. Phys.* **4,** 2, 50–54, Feb. 1953.

An exact treatment is given of the stresses in a flat coil, and account is taken of the spacing between turns by treating the windings as a homogeneous anisotropic material. The results are discussed as a guide to the stresses in thick solenoids. This is followed by a treatment of the stability of the turns of a solenoid against spontaneous deformation, using the principle of virtual work, and criteria for stability are found. It is shown that, in the absence of elastic restraining forces, the outer turns of a thick solenoid would be unstable. From author's summary

Experimental Stress Analysis

(See also Rev. 3677)

3684. Levin, L. R., Strength analysis of stiffened thick beam webs with ratios of web depth to web thickness of approximately 60, *NACA TN* 2930, 11 pp., May 1953.

The results of an experimental investigation of the strength of plane diagonal-tension webs with ratios of web depth to web thickness of about 60 are presented. An analysis of the beams indicated that the methods of strength analysis presented in *NACA TN* 2661 are applicable to beams with the flanges symmetrically arranged with respect to the web, if the portal-frame effect is taken into account. From author's summary

3685. Darling, H. E., and Newhall, D. H., A high-pressure wire gage using gold-chrome wire, *Trans. ASME* **75,** 3, 311–314, Apr. 1953.

Paper describes gold-chromium wire (2.1% Cr in Au) used to measure, by resistance change, pressure up to 150,000 psi. Temperature susceptibility of resistance of gold-chrome is considerably less than conventional manganin, although pressure-resistance coefficient is about 1/3 that of manganin. Time response of gold-chrome is rapid, without drift or hysteresis. Experimental details and data for gold-chrome and manganin are given.

J. T. Bergen, USA

3686. Heebink, B. G., Kuenzi, E. W., and Ericksen, W. S., Evaluation of a vacuum-induced concentrated-load sandwich tester, *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1832-B, 25 pp., Feb. 1953.

Report discusses and evaluates performance of a vacuum testing device which can be used for determining construction quality of flat sandwich panels. Device consists of a dish-shaped casting having a rubber gasket round the rim and a central or axial rubber-covered foot. In operation the central foot and the rim gasket bear against the panel face, after which drawing a partial vacuum loads the panel face, so testing the face-to-core bonding.

Authors conclude that the device is fairly reliable for detecting poor quality construction for some sandwich core materials, e.g., aluminum honeycomb, glass-cloth honeycomb, balsa, but not for others like cotton honeycomb, cellular cellulose acetate, etc. Detailed test results are included, together with a theoretical derivation of the device-induced stresses. Paper is a continuation of earlier work. F. S. Shaw, USA

3687. Taylor, J., Measurement of gust loads in aircraft, *J. roy. aero. Soc.* **57,** 506, 78–88, Feb. 1953.

Paper describes mechanical counting accelerometer weighing only 12 lb which records the number of times the thresholds of acceleration are crossed in steps of 0.1 g between 0 and 2.0 g, and in steps of 0.2 g between −1.0 g and 0 and 2.0 g and 3.0 g. These ranges of acceleration are those most important from fatigue due to gusts standpoint, and they may be expected to occur 10^4 to 10^5 times in the life of an aircraft. Instrument rejects high-frequency acceleration arising from power plant.

Author describes some results obtained on British aircraft and thinks it possible that, eventually, an even simpler accelerometer counting at one acceleration level only may be fitted to every aircraft. Replacement of structural parts would be made when the accelerometer had counted various predetermined numbers, instead of on the present flying-hours replacement basis.

P. C. Dunne, England

3688. Aubaud, J., Photoelastic analysis of a notch (in French), *Rech. aéro.* no. 32, 35–38, 1953.

The method used for determining the fringe value of a photoelastic model may sometimes cause errors. The author investigated a model of a bar with a Neuber notch with a theoretical stress-concentration factor of 4.23. The model material was Markon 7, model thickness 4.5 mm. The fringe value was determined by the aid of a tensile and a bending specimen. The dimensions of the latter were chosen in such a way that the stress gradient in the calibrating bar was the same as that in the original model at the plane of the highest stress. For three different loadings of the model, the fringe value, determined in traction, gave a stress-concentration factor about 15–20% too low; the coefficient following from the fringe value determined in bending was correct to ±2%. The paper contains details of the calibration techniques and a discussion of the results.

R. G. Boiten, Holland

3689. Porubszky, J., New method of measuring stresses in glass (in Hungarian), *Építöanyag* **4,** 1–2 19–26, Jan.-Feb. 1952.

The stressed state of glass is tested by examination of its double refraction. The double refraction to be produced in the compensating instrument has thus far been brought about by plates ground to the proper size, made from a birefringent mineral crystal and fitted into the instrument. Recently, a compensator has been developed which produces the double refraction of known magnitude. This replaces the birefringent crystal needed for testing by means of a homogeneous glass prism, the stressing of which is variable. Results are recorded in kg/cm² by the new instrument. Its use leads to more accurate determination of the magnitude of stresses by the necessary establishment of the k constants. The manufacture of the instrument in any size is simple and inexpensive; it can be used in many fields.

Courtesy of Hungarian Technical Abstracts L. Szepeslublói

3690. Kawata, K., and Tuzi, Z., Studies on the stress-freezing method I, II, *J. sci. Res. Inst., Tokyo* **46, 47,** 199–206, 12–29, Dec. 1952, Mar. 1953.

Part I: (1) The viscoelasticity of phenolite (casted phenol-formaldehyde resin) was studied by torsional experiment of circular cylinder at the temperature range from 60 to 160 C. (2) In shear creep, γ tends to a limiting value at each temperature; and at temperature above about 120 C the limiting value of γ decreases with increasing temperature. The relation between γ and $\ln t$ is linear at some range of t. (3) These experimental results are in good agreement with Tobolsky-Eyring's theory. From this result the values of ΔF_2 and N_2/λ_2 (energy of activation and units of flow, respectively, for secondary network) can be determined. Under some assumptions, ΔF_2 increases but N_2/λ_2 decreases with decreasing temperature (from 100 to 60 C). This result is similar to the result on elastomer obtained by Conant, Hall, and Lyons: $\Delta F_2 = (\text{const})\ T/T - b$. This result, however, should be studied further. (4) It seems that at sufficiently elevated temperature, strain is given by primary bond only at ordinary loading rate, so the elasticity is entropy-elasticity.

Part II: The variations of photoelastic sensitivities α and Young's moduli E of phenolite and a new photoelastic material KT-101 in the temperature range between room temperature and 160 C were studied. The transition from the glassy to the rubberlike state was observed with increasing temperature from room temperature. And it was found that photoelastic sensitivity changed remarkably in the neighborhood of the transition temperature in the same manner as other physical properties, such as thermal expansivity and specific heat. In this rubberlike state, E and $1/\alpha$ were nearly proportional to absolute temperature, and this fact means that these materials exhibit nearly perfect entropy elasticity in this temperature range. It was confirmed that the stress-freezing method is based on the second-order transition of high molecular photoelastic material. A model of photoelastic materials was proposed as was considered more appropriate from the above-mentioned result, and the accuracy of three-dimensional stress analysis by the freezing method was discussed. At last, a new material KT-101 was recommended as a photoelastic material suitable for both the freezing method and usual two-dimensional study at room temperature.

From authors' summary by M. M. Leven, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 3644, 3730)

3691. de Schwarz, M. J., On the characteristics of the torsion function for the neighborhood of corners of solid and hollow bars (in German), *Öst. Ing.-Arch.* **7,** 2, 88–100, 1953.

It is known in specific cases that torsion stresses are infinite at re-entrant angles. In particular, for a re-entrant angle $k\pi$ $(k > 1)$ the shearing stress has the form

$$(\gamma/k)(\rho^{1-k/k}) \sin \theta/k + \ldots .$$

where ρ, θ are polar coordinates with origin at the boundary corner. As $\rho \to 0$, the stress becomes infinite if $\gamma \neq 0$. The author shows proofs that $\gamma < 0$ for re-entrant corners which exist on interior boundaries of a multiply connected region and $\gamma > 0$ for re-entrant corners on the outer boundary of a multiply connected or simply connected region. The proof is given by means of estimates of bounds for the torsion function based upon Picone's theorem on the line integral of the normal derivative of a harmonic function. The author completes the results for the case of an annular section bounded by two concentric similar and parallel-sided regular polygons of n sides. The results have been given previously for the cases of a square and equilateral triangular annular section. D. L. Holl, USA

3692. Matildi, P., On the elastic equilibrium of centrally compressed bars under conventional critical loads (in Italian), *Atti Ist. Sci. Costruz. Univ. Pisa Pubbl.* no. 26, 9 pp., 1952.

Applying the energy method of calculating critical loads, author shows that, in a bar under Euler's critical load, the equilibrium is not indifferent but is unstable. Using in place of the approximate expression of the curvature y the expansion of the true formula in a binomial series, and retaining only the two first terms, the differential equation of the deflection curve is

$$\ddot{y} = (P/EI)\, y\, (1 - 3/2y^2)$$

Substituting this expression in the energy equation $P_{cr} \cdot \Delta v = \Delta T$ the critical load is $P_{cr} = {}_0\int^l \ddot{y}^2(1 - 3\dot{y}^2)dy/{}_0\int^l \dot{y}^2 dy$.

Solving this relation in the case of a bar with hinged ends, and assuming a sinusoidal deflection curve $P_{cr} = P_e[1 - (3/4)\pi^2 (\delta/l)^2]$, then the critical load appears as a function of the deflection δ and approaches Euler's value as δ approaches 0. Although

$P_{cr} < P_e$ when the load reaches Euler's value the straight form of equilibrium becomes unstable.

Reviewer makes the following comment: The above calculation is of theoretical rather than practical interest, because the correction introduced to Euler's value is not significant.

C. A. Sciammarella, Argentina

3693. Aghbabian, M. S., and Popov, E. P., Unsymmetrical bending of rectangular beams beyond the elastic limit, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 579–584, 1952.

Problem is treated under the elementary theory of bending for small strains. It is assumed that plane sections remain plane and that the material is nonhardening. Authors give formulas for the components of the bending moment parallel to the beam sides and the inclination of the applied moment to the beam sides in terms of the direction of the neutral plane, the ratio of the sides, the yield stress, and a parameter depending on the position of the plastic-elastic interface. The rotation of the neutral plane with the spread of the plastic region under increasing moment is discussed. Experimental results for steel specimens are given and compared with the theory. As is to be expected from the approximations involved, the discrepancy between theory and experiment is small at the yield point and increases with strain.

J. F. W. Bishop, Scotland

3694. Öry, H., Calculation of wooden bars subjected to bending and compression (in German), *Acta Techn., Budapest* **5**, 1, 21–45, 1952.

Generalizing well-known theory of W. Prager for pure bending of wooden box beams [*Z. Flugtechnik Motorluftschifffahrt* **24**, 19, 521, 1933; see also Proc. Fourth. inter. Congr. appl. Mech., 237–238, 1935] to include also the effect of compressive force N, author gives diagrams for rupture moment as function of dimensions and of a dimensionless variable φ, containing N. Experiments show excellent agreement with theory.

F. K. G. Odqvist, Sweden

3695. Wright, W., Beams on elastic foundations—solution by relaxation methods, *Struct. Engr.* **30**, 8, 169–171, Aug. 1952.

Plates, Disks, Shells, Membranes

(See also Revs. 3676, 3677, 3678, 3686, 3730, 3794)

3696. Girkmann, K., and Tungl, E., Simplified analysis of rectangular plates, clamped at the circumference (in German), *Öst. Bauzeitschr.* **8**, 3, 47–53, Mar. 1953.

Authors use a particular form of trigonometric series for representation of the deflections $w(x,y)$ and determine the coefficients of the terms involved by application of the principle of least potential energy. Determination of the coefficients turns out to be relatively simple since any coefficient can be expressed by either one of the two coefficients of lowest order.

Authors show that deflections $w(x,y)$ can also be represented explicitly by means of an auxiliary function which is found by solving an inhomogeneous differential equation of the fourth order. A particular integral of this equation is found, making use of the Dirak delta function.

From $w(x,y)$ the curvatures in x and y direction and the twist are determined, from which the bending and torsional moments are derived in explicit form.

A numerical example illustrates the method. The results are compared with those obtained by Timoshenko's strict method and show satisfactory agreement in all cases where the load is not concentrated on too small a portion of the plate.

The article represents a valuable contribution to the theory of plates.

K. Arnstein, USA

3697. Gaafar, I., Hipped plate analysis, considering joint displacements, *Proc. Amer. Soc. civ. Engrs., Pap.* no. 182, 28 pp., Apr. 1953.

The theoretical and experimental investigations indicate considerable error in the approximate theory of Ehlers and Craemer and others.

The first step is to compute the forces and transverse and longitudinal stresses acting on the edges of each plate. The second step is to determine the effect of the relative transverse displacement on the transverse and longitudinal stresses. This is done by choosing relative displacements between consecutive joints as unknowns and solving by the moment-distribution method. The longitudinal stresses from the displacement are then computed in terms of relative displacement and deflections. The solution is next determined by simultaneous geometrical and equilibrium conditions and added to the results of the first step.

Aluminum models have shown average accuracies on the order of 40%, as compared with 200% by more approximate methods.

C. R. Freberg, USA

3698. Fergusson, H. B., Kudar, J., and Harvey, R. B., The stress distribution in the head of a thin-walled pressure vessel, *Quart. J. Mech. appl. Math.* **6**, part 1, 1–14, Mar. 1953.

The stress distribution in the head of a thin-walled vessel formed of zones from various surfaces of revolution is considered. The equations of the membrane theory are written in terms of the meridional arc length and are then shown to have an approximate solution valid for moderate thicknesses of the shell, provided that $R_1 \cot \ll R_2$, where R_1, R_2, are the principal radii of curvature, and φ the inclination of the normal to the axis of the shell. The method is applied to a torospherical vessel head with a large bunged opening in the center. The maximum stresses in this head occur in a hyperboloidal zone and are found to be considerably less than would arise in a comparable toroidal section.

From authors' summary by Ch. Massonnet, Belgium

3699. Müller, W., The moment surface of elastic plates or mushroom floors and the determination of the deflections from the moments (in German), *Ing.-Arch.* **21**, 1, 63–72, 1953.

In an earlier article [AMR 6, Rev. 1232], author presents solutions for the deflection for various loadings on rectangular plates and mushroom floors. The present article considers two special cases, namely, the simply supported rectangular plate with point loading, and the continuous mushroom floor with point supports, utilizing theta functions for numerical evaluation of the moment surface $M = (m_x + m_y)/(1 + \nu)$. He also shows, in the case of the mushroom floor, how the expressions for the moment surface may be integrated to obtain the deflection and the boundary conditions satisfied. The relation to analogous hydrodynamic problems is noted.

For those able to cope with the mathematics of elliptic functions of a complex variable, the author provides an alternative method of attack on plate problems to the familiar methods of Nàdài and others.

A. Burn, Australia

3700. Mikhlin, S. G., Estimate of the error in the computation of an elastic shell as a flat plate (in Russian), *Prikl. Mat. Mekh.* **16**, 4, 399–418, July-Aug. 1952.

If an open shell and a plate, both of the same thickness and the contour of the plate being the greatest projection of the contour

of the shell, are identically loaded and supported, then the difference of their potential energies will depend upon the curvatures of the shell; the smaller the curvatures the smaller the difference. This difference, divided by the energy of the plate, the author calls the error in the computation of a shell as a plate. He considers only shells of small curvatures, and most of his paper deals with the derivations of convenient formulas and estimates of the energies of shells and plates. He presents an example of a helical shell where the error is less than 18%. The estimate of the error gives a better insight to the theory of shells of small curvatures, which the Russians call "sloping shells." The definition of a sloping shell is as follows: Given an element of an arc of a shell $ds^2 = A_1^2(a_1, a_2)da_1^2 + A_2^2(a_1, a_2)da_2^2$ and an element of an arc of a plate

$$ds_0^2 = B_1^2(a_1, a_2)da_1^2 + B_2^2(a_1, a_2)da_2^2$$

where a_1 and a_2 are curvilinear coordinates, if $|A_i - B_i|$ and $|\partial A_i/\partial a_k - \partial B_i/\partial a_k|$ are sufficiently small as compared with the smallest values of B_1 and B_2, then the shell is said to be a sloping shell.

The new insight is used by the author to present a new theory of sloping shells which differs from the existing theories of Vlasov ["General theory of shells and its applications in technology," Moscow-Leningrad, 1949] and Nazarov [AMR **4**, Rev. 631]. The author points out also an error in Nazarov's work.

Courtesy of Mathematical Reviews T. Leser, USA

3701. Dallison, K. J., Stress analysis of circular frames in a nontapering fuselage, *J. roy. aero. Soc.* **57,** 507, 151–176, Mar. 1953.

Method is developed for analysis of flexible fuselage rings having large cutouts such as occur at cargo and bomb doors. Frame and skin are divided into segments, then strain-energy expression for skin shear and frame bending is minimized, using Lagrange's undetermined multipliers. Resulting simultaneous equations are solved by relaxation or any of several other discussed standard numerical procedures. Numerical example for a partial bulkhead is included in detail, showing effects of stringer and skin end load. Application of method to closed rings is not worked out.

Nonmathematical discussion and summary of major previous literature make this an excellent introduction to ring analysis.

C. M. Tyler, Jr., USA

3702. Giuliano, L., On the equilibrium of an infinite strip, built in and simply supported (in Italian), *Ann. Scu. norm. sup. Pisa* (III) **6,** 3–4, 147–171, July-Dec. 1952.

A solution of the classical plate equation satisfying the boundary conditions for one edge simply supported and the other perfectly clamped is obtained by means of the Fourier transform method used by Ghizzetti to solve the problem of an infinite strip built in along both edges [*Rend. Mat. appl. Rome,* 1947, 145–187]. For a large class of external loading functions $f(x, y)$ the vertical deflection is given by

$$u(x, y) = (1/8\pi D) \int_0 \int G(x, y, \xi, \eta) f(\xi, \eta) d\xi d\eta$$

where G is Green's function of the problem.

F. DiMaggio, USA

3703. Federhofer, K., On the eigenfrequencies of cylindrical shells of circular cross section and variable thickness (in German), *Österr. Akad. Wiss. math.-nat. Kl. S.B.* IIa **161,** no. 4–6, 89–105, **1952.**

Eigenfrequencies and eigenfunctions are obtained for axially symmetric torsional and bending-extensional vibrations of constant thickness shell. Wall thickness is taken as function of small parameter μ and axial distance along shell. Perturbations in μ of constant-thickness solution with orthogonality condition are used to obtain solution for wall-thickness linear and quadratic function of distance along shell axis. R. P. Felgar, Jr., USA

3704. Berger, E. R., On the calculation of the influence field of a square plate (in German), *Ing.-Arch.* **20,** 3, 207–210, 1952.

Author proves the incompleteness of Pucher's trigonometric series in the special case of an influence-field of a single bending moment at the boundary in the middle of one edge (all edges built in) [Pucher, title source, **12,** S.76, 1941]. The completed trigonometric series are identical with certain biharmonic polynomial functions, which were already used by Pucher [ibid.].

F. Müller-Magyari, Austria

3705. Peter, L., Determination of the state of plane stress in a cylinder of elliptical cross section (in Italian), *Ann. Scu. norm. sup. Pisa* (III) **6,** 3–4, 255–267, July-Dec. 1952.

Author starts from Ghizzetti's work [AMR **4,** Rev. 1038] giving three stresses t_{xx}, t_{yy}, t_{xy} of the plane elastic state, using three arbitrary constants and an arbitrary analytic function

$$\varphi + i \cdot \psi \text{ of } x + i \cdot y$$

$\phi(x,y)$ being furthermore a solution of the equation $\Delta_2\phi = F(x,y)$. The first derivatives of $F(x,y)$ express the components of body forces. He obtains in general the normal component t_{nn} on the boundary of the plane field D section of the elliptic cylinder with the planes z = const, which allows reducing the problem to building up a harmonic function φ in the D field, and expressing φ by elliptic confocal coordinates $\varphi(\rho,\theta)$.

Conditions are given under which the solution will be univocal. The Fourier coefficients of $\varphi(\rho,\theta)$ are determined as functions of θ, from which results for φ a double series representing Green's $G(\rho,\theta,\tau)$ function of the problem. Then the three constants α,β,γ are calculated by means of three compatibility conditions, body forces being considered null, $\phi(x,y)$ being 0.

Finally, $\partial G/\partial x$, $\partial G/\partial y$ being calculated, the expressions of the stresses are obtained. From the author's general formulas it is concluded that it is possible to reach, as a special case, M. G. Platone's formulas for the circular cylinder [AMR **5,** Rev. 1016].

A. Guzmán, Argentina

Buckling Problems

(See also Rev. 3692)

3706. Neuber, H., Theory of pressure stability of the sandwich plate. I, II (in German), *ZAMM* **32, 33,** 11/12, 1/2; 325–337, 10–26, Nov./Dec. 1952, Jan./Feb. 1953.

It is not a proper sandwich plate that author deals with, but rather a column, the edges in the direction of pressure not being guided. His objective is to find the thickness and weight of the layers so as to maximize the thrust load. As the problem is a two-dimensional one, where $\sin \varphi x$ can be put outside a parenthesis, integration requires e-functions with two or three sets of constants of integration according to the number of layers. The equation for the eigenvalue is solved by linearization, which will result in a set of diagrams showing the critical load vs. thickness h_1 of the thin layer, first with h_1/h (h thickness of the thick layer), then with the total weight, as parameters. An optimum diagram shows the superiority of the three-layer plate.

K. Marguerre, USA

3707. Gittleman, W., Laterally loaded non-uniform struts, *Aircr. Engng.* **25,** 288, 56–57, Feb. 1953.

3708. **Duberg, J. E., and Wilder, T. W., III, Inelastic column behavior,** *NACA Rep.* 1072, 16 pp., 1952.

Supersedes article reviewed in AMR 4, Rev. 1987.

3709. **Hickman, W. A., and Dow, N. F., Direct-reading design charts for 24S-T3 aluminum-alloy flat compression panels having longitudinal formed hat-section stiffeners and comparisons with panels having Z-section stiffeners,** *NACA TN* 2792, 71 pp., Mar. 1953.

Charts, based on extensive test data of *TN* 1157, 1439, and 1553, are given in two alternate forms. These charts make possible the direct determination of the stress and all panel proportions required to carry a given intensity of loading with a given skin thickness and effective length of panel. Some illustrative examples are discussed in detail. A comparison is made of the relative merits of hat- and Z-stiffened panels when used for carrying simple compression and when used as the cover of box beams subjected to compression plus bending, or to compression plus bending plus shear. The latter comparisons are based on some additional box-beam tests. The hat-section stiffener appears to be structurally better than the Z-section stiffener for only a limited range of applications. F. J. Plantema, Holland

Joints and Joining Methods

3710. **Möller, T., New method for the calculation of nail-wood connections** (in Swedish), *Trans. Chalmers Univ. Technol.* no. 117, 77 pp., 1951.

Paper contains a method for calculating the bearing capacity of nailed wood connections on the basis of the assumption that nail and wood are to be regarded as elastoplastic. With this basic assumption, K. W. Johansen has previously deduced formulas for the bearing capacity [K. W. Johansen, *Byggn.-stat. Medd., Copenhagen* **12,** 1941]. Author's formulas are, in principle, in accord with those deduced by Johansen.

Author investigates the value of the contact pressure between nail and wood at failure in experiments with nails with large stiffness. He finds very little influence of the largeness of cross section. Furthermore, he finds that nails with quadratic cross section are superior to nails with circular cross section. The difference is remarkable. His critical analysis of his experi nental results shows that the plastic theory is applicable. Furthermore, the experiments give constants of materials for design.

The tests are short-time tests. As author points out, supplementary long-time tests should be valuable.

H. Nylander, Sweden

3711. **DeLollis, N. J., Properties and uses of 43 adhesives classified according to chemical type,** Prod. Engng., Annual Handbook of Prod. Design for 1953, G6-G9.

3712. **Goldberg, J. E., Stiffness charts for gusseted members under axial load,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 179, 15 pp., Mar. 1953.

Paper presents charts on the basis of which allowance could be made for extra stiffness of gusset-plate connections of truss members when calculating secondary stresses and buckling loads. The charts are given as functions of certain parameters, for whose determination the author suggests an approximate method based on application of ordinary flexural theory to deformation of gusset plates. The reviewer considers this method as oversimplification, which ignores the complex stress condition in the gusset plate and the deformability of the joining elements. In his opinion, this makes the parameters unknowable and the charts impossible to use. A. Hrennikoff, Canada

Structures

(See also Revs. 3646, 3660, 3671, 3672, 3737, 3754, 3793, 3879)

3713. **Morrison, I. F., Group loadings applied to the analysis of frames,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 183, 15 pp., Apr. 1953.

One classical method for the solution of a statically indeterminate frame involves selection of a primary structure (usually statically determinate) and a system of redundants. The following loading conditions are then established: (a) Primary structure loaded with the actual system of external loads (condition $X = 0$), and (b) primary structure loaded in turn with each of the redundants, which are taken equal to unity and applied separately (conditions $X_k = 1$). Work or deflection considerations then permit the establishment of a set of simultaneous equations which can be solved for the values of the redundant forces. Author utilizes his "group-loading" method to reduce the labor involved in the solution of these simultaneous equations.

A set of redundant groups Y_m is established. Each Y_m group consists of a particular combination of the X-redundants, each multiplied by a coefficient. In effect, the values of these coefficients are chosen so that, when work equations are formulated for the Y_m groups, a set of equations containing only one unknown each is obtained. These are solved directly for Y_m. The actual values of the redundants X_k then can be obtained by evaluating expressions relating each X_k to the values of Y_m and to the magnitudes of the redundants in the conditions $Y_m = 1$.

Reviewer believes this procedure to possess merit for certain structures. Nevertheless, the amount of labor required in its application is frequently considerable, and a good degree of skill is required for its most effective application.

H. Simpson, USA

3714. **Bolton, A., The analysis of multi-bay gabled rigid frames,** *Struct. Engr.* **31,** 4, 110–117, Apr. 1953.

A method of analysis is presented in which the gabled portion of the frame is replaced by an equivalent beam of the same axial and rotational stiffness. After determining the carry-over factors and the distribution coefficients for rotations and sways, the analysis can readily be made by relaxation of the constraints of the equivalent structure. The method is illustrated by a five-bay gabled frame of unsymmetrical geometry and loading, which shows the straightforward procedure suggested.

G. G. Meyerhof, Canada

3715. **Michielsen, H. F., and Dijk, A., Structural modifications in redundant structures,** *J. aero. Sci.* **20,** 4, 286–288, Apr. 1953.

Attention is drawn to a method of determining the variation in the forces in members of a statically indeterminate structure, such variation being caused by changes in one or more members of the structures. The method should be of particular interest to designers, since it obviates the necessity of completely reworking an analysis after the proportions of some members had to be changed to avoid excessive stresses. Reviewer believes that the procedure deserves a more complete description, particularly since it may have applications outside the structural field.

L. Schenker, USA

3716. **Strigl, G., General approximation methods for calculation of highly statically indeterminate systems** (in German), *Stahlbau* **21,** 9, 10; 167–170, 192–196, Sept., Oct. 1952.

Author demonstrates that the iteration method of Drehwinkelausgleich [rotation-angles equalization] as well as the iteration

method of Momentenausgleich [moment equalization] can be deduced from the Formänderungsgrössenverfahren [slope-deflection method of Ostenfeld] (deformations used as unknown quantities); in both iteration methods, starting from the geometrically determinate system, the conditions of equilibrium are fulfilled stepwise; whereas in the iterative calculation of the Kraftgrössenverfahren [force quantities method] (using forces and/or moments as unknowns), the conditions of deformation are fulfilled stepwise.

The Momentenausgleichverfahren [method of moment equalization] is identical with the Cross method which, in case of sideways (i.e., relative displacements of the ends of the bars or rotations of the bars), is simplified by introducing as unknowns of the slope-deflection method, in usual manner, the Stabdrehwinkel [bar rotation angles] and the Knotendrehwinkel [joint rotation angles] (cf. simplified Cross method of Da Silva Jr., AMR **5**, Rev. 1054).

When the system which results from replacing the rigid joints by articulations has one or more degrees of freedom, the convergence of the usual iteration method is bad, but can be improved in the following manner: At first the bar rotation angle is approximately computed by means of carry-over factors, and then this estimated quantity is introduced in the iteration calculation by an addition ["Vorgabe"] which is subtracted in the next step.

These methods are demonstrated by two examples (plane and space frames) with suitable tabulations. Moreover, it is demonstrated that, in the case of a symmetrical system, the calculation can be shortened by use of sums and differences of deformations ["Gruppenverformungen"] as unknowns.

In some cases, it is preferable to use the iteration method of the Kraftgrössenverfahren [force-quantities method] which is demonstrated by a third example (continuous beam on elastic supports).

The different methods described are generally compared with regard to their suitable applicability. Occasionally a combination of the Kraftgrössenverfahren [force-quantities method] and the Formänderungsgrössenverfahren [slope-deflection method] is advantageous.

The paper is a valuable contribution to the problem of highly statically indeterminate systems, as well as to the general question as to which of the numerous iteration methods is to be preferred in each case [cf. Worch, "Rahmenberechnung," etc., Stahlbautagung, 1952. Abhandlungen aus dem Stahlbau, Heft 12; p. 10-5f. Industrie-und Handelsverlag, Walter Dorn, G.m. b.H. Bremen-Horn, Germany]. E. Seydel, Germany

3717. Bettess, F., A graphical determination of moments in rigid frameworks, *Civ. Engng. Lond.* **47, 48,** 558, 559; 1009–1010, 72–74, Dec. 1952, Jan. 1953.

Valves of moments in rigid frameworks are graphically determined by locating characteristic points; final positions of characteristic points are located by successively locking and unlocking joints. Process is similar to that of moment distribution. Procedure is outlined and several example problems are given.

C. M. Smith, USA

3718. Johnson, A. I., Strength, safety and economical dimensions of structures, *Instn. Byggnadsst. Medd.* no. 12, 159 pp., 1953.

This is an expository treatment of the problems introduced by statistical variations in homogeneity of material, dimensions of members, and applied loading. Statistical discussion is based on normal distribution and distribution of largest value in a sample. Proposal for most economical design is essentially to minimize the mathematical expectation of total cost. Included is a rather sketchy discussion of how theoretical statistical treatment can be brought into satisfactory agreement with experience. Reviewer believes the author's approach is pertinent to the formulation of building design codes, but not feasible for the designers.

G. W. Housner, USA

3719. Koloušek, V., Analysis of continuous arches of equal spans on piers of equal heights (in Czech), Anniv. Vol. Zdeněk Bažant, Praha, Technic.-Vědec. Vydavat., 143–170, 1952.

Author presents a simplified analysis of continuous arches of identical shape, span, and stiffness on piers of equal height and stiffness by using method of deformations, whereby the redundants—horizontal displacements and angular rotations at the supports—are determined by trigonometric series. The number of interdependent equations are thus reduced to two, if vertical displacements are neglected. Presented method can also be modified for consideration of vertical displacements; in this case, a series of three interdependent equations results, to be solved in a similar way. The method can be used for continuous arches arranged along straight axis or in a polygonal arrangement (space structure). J. J. Polivka, USA

3720. Raithel, A., Dynamics of stiff-jointed systems. Note I: Free vibrations of systems having undisplaced joints (in Italian), *G. Gen. civ.* **90,** 11, 629–635, Nov. 1952.

Continuous beams and frameworks are considered. In a single self-standing span, the deflection curve is determined through four end conditions; the vibration being free, their system is homogeneous, and the well-known frequency equation is derived.

In a beam on n supports the $4n$ conditions are successively reduced to a system of n continuity equations: these are three-moment generalized equations in which inertia loads are taken into account.

In this and similar cases, author suggests a step-by-step method to solve the complicated frequency equation. Let a single span be taken apart and suppose that the remaining structure vibrates with a given first-approach value of the frequency. The isolated span shall then behave as a beam under elastic constraints whose stiffness is independent from the mode of vibration of the beam. A second approximate value of the natural frequency can thus be derived for the single span, and so on. The true value always remains between two successive approximations.

Author applies Cross moment-distribution method to calculate the end rotation of a continuous system for a unit moment oscillating with a given frequency; the expressions of stiffness and carry-over factors are generalized to take into account inertia loads along the beams. D. Gentiloni-Silverj, Italy

3721. Raithel, A., Dynamics of stiff-jointed systems. Note II: Free vibrations of systems having free joints (in Italian), *G. Gen. civ.* **90,** 12, 716–721, Dec. 1952.

This second note deals with frameworks in which joint displacements are allowed. Each girder vibrates as a concentrated mass M_i according to the dynamic equilibrium equation $F_i = \sigma^2 M_i \delta_i$, δ_i being the displacement and F_i the sum of all shear forces carried from the columns on the girder.

We may write $F_i = \Sigma_k \delta_k f_{ik}$, where f_{ik} is the whole shear force when displacements of single girders are prescribed as follows

$$\delta_k = 1 \qquad \delta_j = 0 (j \neq k)$$

Author derives f_{ik} values by applying Cross generalized method; namely, in each condition the frame undergoes unit displacement and consequent inertia loads together.

The frequency equation is solved step by step, first by putting the inertia forces equal to zero (overestimated frequency value

is obtained), and next by computing these forces according to the approximate value. A second underestimated value is thus evaluated, and so on.

Examples are developed for single- and two-storied frameworks.

D. Gentiloni-Silverj, Italy

3722. Pugsley, A. G., A simple theory of suspension bridges, *Struct. Engr.* **31,** 3, 75–82, Mar. 1953.

An approximate analogy is established between suspension bridges and beams on elastic foundations. The analogy is based on the fact that a (small) moving load on a suspension cable causes an approximately constant deflection of its loading point (provided the points near the ends of the cable are disregarded). The analogy permits the use of formulas derived for elastically supported beams to calculate moments in the stiffening beam of the bridge. An estimate of the spring constant of the equivalent foundation is given in terms of the weight of the structure per unit length and the dip of the cable.

Reviewer feels that although the analogy is quite useful for giving a method of visualizing the effects of changes in some of the design parameters, the results of the numerical calculations in their present form are rather crude, even for preliminary designs.

G. Sved, Australia

3723. Fraenkel, S. J., and Grinter, L. E., Nonelastic behavior of bridges under impulsive loads, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 185, 20 pp., Apr. 1953.

Deformation of bridges (extending to plastic range) is considered for loads varying with time. Elastic deformation is obtained by step-by-step integration, plastic deformation by assuming the bridge behaves as a mechanism with one member yielding. Predicted deflections of railway spans of 50 to 519 ft resulting from atomic-bomb exploding at height of 2000 ft are given.

R. N. Arnold, Scotland

3724. Ljungström, O., Wing structures of future aircraft, *Aircr. Engng.* **25,** 291, 128–132, May 1953.

A survey is presented on minimum-weight investigation of wing structures, carried out in Sweden. Some results are shown in typical charts for sweptback and delta wings. Structural development, including multicell construction, adhesives, integrally stiffened panels, sandwich and plastics, is critically discussed. Finally, the use of new materials, especially in connection with requirements from temperature considerations, is reviewed.

H. F. Michielsen, USA

3725. Lazzarino, L., Rules and norms concerning airplane structures (in Italian), *Aerotecnica* **33,** 1, 87–93, Feb. 1953.

Following a general introduction in which the limited value of all existing structural airworthiness requirements is emphasized, author gives a comparative discussion of six sets of Italian, French, British, American, and international requirements. Maneuvering loads, gust loads, and ground loads are discussed and criticized. The considerable differences existing between different requirements are repeatedly stressed, but no details are given. In contrast to author's very critical attitude with regard to existing requirements are some of his statements concerning maneuvering and gust loads, which surely would need some substantiation.

F. J. Plantema, Holland

3726. Howe, D., Analysis of two-cell swept box with ribs parallel to the line of flight under loading by constant couples, *Coll. Aero. Cranfield Rep.* 64, 12 pp., Mar. 1953.

Method of oblique coordinates developed by Hemp [title source, 31, Jan. 1950] is used to analyze problem. Box is rectangular, and ribs are assumed continuously distributed, the rib boom area and stringer area being distributed over the skins. Effects of root constraint are not investigated. Results are presented in the form of cross-sectional rotations and stress resultants.

From author's summary by A. D. Topping, USA

3727. Horne, W. B., Static force-deflection characteristics of six aircraft tires under combined loading, *NACA TN* 2926, 92 pp., May 1953.

Experimental data are presented for the elastic properties of six aircraft tires from 27 in. to 56 in. in diam. These data provide information on (1) the vertical lateral, longitudinal, and torsional spring constants for some of these tires for a range of vertical loading and inflation pressure, (2) the shift of vertical load center of pressure under lateral and longitudinal loading, (3) the variation of internal pressure with load, and (4) for one tire, the shape of the lateral distortion curve of the tire circumference under lateral loading.

R. F. Smiley, USA

3728. Wittrick, W. H., Torsion and bending of swept and tapered wings with rigid chordwise ribs, *Aero. Res. Consult. Comm. Australia Rep.* ACA-51, 85 pp., Sept. 1950.

The problem considered is that of a swept wing, either conical or cylindrical, of arbitrary section, under any system of bending and torsion loads. The wing is assumed to consist of a nonbuckling outer skin, a series of booms and stringers located along generators of the tube, and a series of closely spaced ribs all parallel to the root section. The ribs are assumed to be completely rigid in their own planes but to offer no resistance to warping out of their planes. For simplicity, only single-cell tubes are considered.

The theory is developed in general terms for arbitrary section, arbitrary variation of stress bearing area over the tube, and arbitrary applied loads. No restriction is placed on either the taper or the sweep of the tube. The fundamental equations are expressed in terms of a stress function which is found to satisfy a complicated integrodifferential equation. Analytical solutions of this equation are obtained in certain cases by a process consisting essentially of separation of the variables. These solutions show an interaction between torsion and bending which is characteristic of this type of wing.

In the case of a swept wing which is only slightly tapered, it is shown that, except in regions near the root and near a heavy concentrated shear load, the deformations and stresses under arbitrary loading may be obtained by a method which is essentially an extension of the simple theory of bending and torsion for an unswept wing. The computation can all be done in tabular form and is illustrated numerically. As yet, no method convenient for dealing with the restricted regions has been found.

In the case of a highly tapered wing, it is shown that the root effect is of prime importance, since the stresses arising from the warping constraint at the root decay very slowly along the length of the tube. This fact considerably complicates the analysis of such wings.

The comprehensiveness and clarity of the above are to be commended.

From author's summary by R. E. Heninger, USA

3729. Horne, M. R., Model to illustrate the behaviour of fixed base portal frames in the plastic range, *Brit. J. appl. Phys.* **4,** 2, 54–55, Feb. 1953.

The model described reproduces the modes of collapse of a fixed-base steel portal frame as predicted by the plastic theory. It is composed of light alloy cubes held together by fine steel wires, the tensions in which determine the strengths of the corresponding

members in the structure. Good quantitative agreement is obtained between the observed and theoretical loads necessary for collapse. It is suggested that similar models could be constructed to study the behavior of more complicated frames.

From author's summary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 3681, 3723, 3753)

3730. Hoffman, O., and Sachs, G., Introduction to the theory of plasticity for engineers, New York, Toronto, London; McGraw-Hill Book Co., Inc., 1953, xiv + 276 pp. $6.50.

The text is organized into four parts. In part I, states of stress and strain are defined and elastic behavior is stated briefly. Tensor notation is used. In addition to brief mention of some of the older theories of failure, the maximum shear and von Mises yield conditions and "yield surfaces" are discussed. The plastic stress-strain relations described are of two types—the universal stress-strain law or deformation theory, and the Saint Venant theory of flow. Reuss's theory and Hencky's theory are, respectively, refinements and approximations of Saint Venant's theory for the use of small plastic deformations. In the section on experimental data, the authors point out that the restrictive nature of some of the present assumptions prevents too close an agreement between theory and experiment.

In part II, the nonstrain-hardening or ideally plastic case is considered. The problems discussed are those of thick-walled spherical shells and thick-walled tubes under internal pressure, rotating cylinders and disks, and torsion and bending. The plastic deformations are "contained and limited" to small values. The problems have certain common simple features such as symmetry in geometry, loading and boundary conditions.

In part III, torsion and bending problems are solved again for the strain-hardening case. The buckling of compressed bars and the instability of bars, plates, tubes, and shells due to "necking" in tension are discussed.

Part IV comprises almost two fifths of the book and goes into some detail on the stress distributions in ductile metals subjected to large plastic deformations during forming processes. The authors state that elementary rather than rigorous solutions of the problems are presented because the former often yield surprisingly good results and also because some features of the existing rigorous solutions are not supported by experimental evidence.

Summarizing, this text consists of a well-written presentation of some of the currently used theories of plasticity as well as of a collection of existing elementary solutions to many interesting and important problems of plasticity. Y.-H. Pao, USA

3731. Prager, W., A geometrical discussion of the slip line field in plane plastic flow, *Trans. roy. Inst. Technol. Stockholm* no. 65, 27 pp., 1953.

Author points out present limitations of analytical or numerical methods for solving problems of plane plastic flow. These methods are mostly restricted to examples where problem is either statically determinate or solution contains straight slip lines. Paper here describes graphical methods of more general application. Author gives concise explanation of and relations between physical, stress, and hodograph planes; he shows how three types of boundary-value problems may be solved and takes an example in sheet extrusion. Reviewer found geometrical discussion of theory of considerable interest.

D. N. de G. Allen, England

3732. Graham, A., The phenomonological method in rheology, *Research* 6, 3, 92–97, Mar. 1953.

Features of rheology suggest that models and some accepted principles cannot be relied upon to lead to an adequate mathematical theory. A progressive method of building up a theory by direct reference to experiment is described and is shown to lead to a particular differential equation. From author's summary

3733. Johnson, R. D., Shober, F. R., and Schwope, A. D., The creep of single crystals of aluminum, *NACA TN* 2945, 51 pp., May 1953.

Paper has a fundamental and theoretical, rather than engineering approach. It presents good transient-creep data for 99.99% pure aluminum crystals, which seem to fit Andrade's empirical relation that the shear strain rate is proportional to $t^{-2/3}$ (where t is time). Paper includes a qualitative review of plastic-flow behavior in terms of dislocation theory. A. N. Holden, USA

3734. Rabotnov, Y. N., Some problems of the theory of creep, *NACA TM* 1353, 19 pp., Apr. 1953.

See AMR 4, Rev. 2030.

3735. Clarke, N. W. B., and Walley, F., Creep of high-tensile steel wire, *Proc. Instn. civ. Engrs.* 2, part 1, 107–135, Mar. 1953.

Paper gives results of engineering rather than fundamental importance on the stress-relaxation of "high tensile strength steel" wire stretched and maintained at constant length. Greater stress relaxation was found at higher initial stress levels. At any initially applied stress, the stress relaxation was proportional to log time up to 1000 hr, the time limit of tests.

A. N. Holden, USA

3736. Mott, N. F., The mechanism of work-hardening of metals, *Instn. mech. Engrs. Proc.* (*A*) 166, 4, 413–418, 1952.

See AMR 6, Rev. 1245.

3737. Meacham, R. C., Theory of creep in pin-jointed structures, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 619–624, 1952.

Author uses a linear creep-rate law and studies viscoelastic trusses and viscoelastic-plastic trusses by using a reduced stress space procedure. By this procedure, a geometric construction can be made showing the motions of the stress point, the residual stress point, and the set point during several time intervals when the truss is subjected to a constant load or to a specified load sequence. B. E. Gatewood, USA

3738. Geiringer, H., On the general plane problem of a perfectly plastic body, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 539–545, 1952.

The general plane problem is discussed on the basis of representations in three planes: The physical plane, the "stress graph," and the "velocity plane." Simple approximate solutions of initial value problems are based on the relations between the three planes and their characteristics. The compatibility relations, holding along each characteristic, are discussed. Theory is applied to the problem of "simple waves."

W. T. Koiter, Holland

3739. Hill, R., A note on estimating yield-point loads in a plastic-rigid body, *Phil. Mag.* (7) 43, 338, 353–355, 1952.

Bounds are obtained for the error commited when any approximate theory of plasticity is used to estimate yield-point loads. It is shown, for example, that, if the von Mises yield func-

tion and potential are used to approximate the Taylor-Quinney data for copper, the error is less than 1% for a wide variety of loading programs.

From author's summary by D. R. Bland, England

3740. Marin, J., and Hu, L. W., On the validity of assumptions made in theories of plastic flow for metals, *Trans. ASME* **75,** 6, 1181–1190, Aug. 1953.

Thin-walled 14S-T6 Al tubes have been stressed in biaxial tension in order (1) to test the applicability of both the distortion energy and slip criteria for yielding under combined stresses, and (2) to show the deviations from constant volume which occur during plastic deformation. Specimens are loaded to prescribed ratios of axial tension and internal pressure. Axial and lateral strains are measured with wire strain gages; radial compressive stresses are neglected. Results of tests varying stress combinations within the "yield surfaces" as defined by the two yield theories lead the authors to conclude that the slip theory is a better yield criterion for this material. The volume is shown to change during plastic deformation.

Reviewer believes clarity would be enhanced by showing the relationship between proportional limit and yield stress and by more discussion of reasoning behind conclusions drawn from Figs. 8 and 10. J. M. Krafft, USA

3741. Nadai, A., The principle of minimum work applied to states of finite, homogeneous, plane, plastic strain, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 479–485, 1952.

Sequences of finite homogeneous plane strain for an ideally plastic substance are defined by plotting in a plane figure the conventional finite shear as a function of the quadratic finite elongation (the square of one plus the unit strain) for two straight lines which, in the unstrained condition of the body, were perpendicular. The plastic work of deformation is evaluated for different sequences originating in the unstrained and ending in the same strained condition of the body. There is one and only one particular pathway for which the axes of the incremental tensor of strain continuously coincide with the axes of the tensor of finite strain. For this sequence of finite strains, the work of permanent deformation is a minimum. It is shown that the curves corresponding to these minimum work sequences are the extremal curves of the Euler differential equation of the problem of variational calculus for the minimum of plastic work done.

From author's summary by J. Heyman, England

3742. De Simoni, F., On a particular three-dimensional problem in the theory of plasticity (in Italian), *Ist. Lombardo Sci. Lett. R. C. Cl. Sci. Mat. Nat.* (3) **15** (**84**), 623–634, 1951.

In the absence of body forces, the fundamental equations of the von Mises theory of plasticity contain the following unknown functions of position: The mean normal pressure p, the components s_{ij} of the stress deviation, the velocity components v_i, and a positive factor of proportionality λ between the components of the velocity strain and the stress deviation. B. Finzi [*Atti Accad. Sci. Torino* **76,** 222–238, 1941] derived a reduced system of equations containing only the stress deviation components s_{ij}. (Another reduced system containing only p and the velocity components v_i was given recently by T. Y. Thomas [AMR **5,** Rev. 2825].) The present author remarks that, for the purpose of constructing particular solutions, it may be preferable to use a less reduced system of equations of lower order. As an example, he uses equations involving p, λ, and v_i to study solutions for which the velocity components v_i depend in an exponential manner on a linear form of the coordinates x_1, x_2, and x_3. He finds that the stress field is uniform in this case. (The author seems to be unaware of the fact that he has not actually found a three-dimensional flow. Since the determinant of the strain-rate components vanishes, one of the principal strain rates is zero and the flow is plane.) W. Prager, USA

Failure, Mechanics of Solid State

(See also Revs. 3687, 3730, 3740, 3747, 3752)

3743. Cazaud, R., Fatigue of metals (translated by Fenner, A. J.), New York, Philosophical Library, 1953, xiv + 334 pp. $12.50.

See AMR **2,** Rev. 869.

3744. Tipper, C. F., Dimensions in testing, Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Pap. no. 458, 21 pp., May 1953.

Author outlines and discusses test results in transition temperature studies from the viewpoint of specimen shape and size. The survey covers the principal aspects of the subject from the statistical approach of Weibull and the early work of Davidenkov through the work of the past decade, principally in this country. The main conclusions are that dimensions are relatively unimportant except in the presence of a notch. The initiation and propagation of a fracture in a notched specimen are determined to a large extent by the dimensions. Available material on the mechanism of fracture is reviewed in the light of these conclusions. G. S. Cherniak, USA

3745. Grover, H. J., Hyler, W. S., Kuhn, P., Landers, C. B., and Howell, F. M., Axial-load fatigue properties of 24S-T and 75S-T aluminum alloy as determined in several laboratories, *NACA TN* 2928, 63 pp., May 1953.

The results of axial-load fatigue tests at stress ratios from −1.0 to 0.6 obtained at one laboratory on sheet specimens of aluminum alloys 24S-T3 and 75S-T6 are compared with similar results obtained with two different types of axial-load fatigue machines at two other laboratories on the same alloys. Also, comparison is made with axial-load fatigue tests made at a fourth laboratory on round specimens from rod material of these alloys.

For the 24S-T3 material, the agreement among the results obtained at all four laboratories is excellent. For the 75S-T6 material, good agreement is observed only for the sheet specimens tested at medium stress levels. However, notable differences exist between results for 75S-T6 sheet specimens tested at low stress levels and between results for rod and sheet specimens at all stress levels. Results do not indicate whether differences can be attributed primarily to variability of material or to variability of test conditions. J. A. Bauscher, Jr., USA

Material Test Techniques

(See also Revs. 3744, 3755)

3746. Braun, A., Irregularities in the phenomenon of microhardness (in French), *Schweiz. Arch.* **19,** 3, 67–78, Mar. 1953.

A theoretical analysis of the hardness test is made, based on the deformation of a spherical cavity in an infinite medium. This is compared with the simple tension tests, and from this is obtained the form for the equation relating hardness to tensile properties. Both elastic and work-hardening materials are treated, the latter equation having an extra term. It is thus possible to account for variations in hardness values obtained by testing a material under different penetrator loads. A testing

procedure is described, with complete description of how the material constants are calculated. Good agreement of tests and theory is reported. It is claimed that hardness variations, when measured at different elevated loads, give relations to the structure of the material. Penetrator loads from 2.5 to 50,000 grams were used in tests. T. A. Hunter, USA

3747. **Matton-Sjoberg, P., The mechanism of fracture in impact tests,** Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Pap. no. 454, 46 pp., May 1953.

A series of tests on mild steel was made, using the standard Charpy keyhole and the Schnadt K_0 impact tests. The experimental method is described and the chemical analyses of the specimens given. The mechanism of fracture of different metallurgical structures is discussed. The paper concludes with a summary of the factors involved in brittle fracture.

From author's summary by R. G. Boiten, Holland

3748. **Dodge, B. F., High pressure research in chemical engineering department of Yale University,** *Trans. ASME* **75,** 3, 331–343, Apr. 1953.

A rapid "Cook's tour" through the five-year-old, high-pressure laboratory is followed by a digest of past and future research projects. Hydrogen attack on metals at pressures up to 2000 atm and temperatures up to 500 C is reviewed qualitatively on the basis of three different types of experiments. While no theory is presented, certain findings are of quite wide interest, such as the severe hydrogen attack of low and medium chrome steels at pressures above 1000 atm.

Compressibility of H_2–N_2 gas mixtures is discussed at various concentration levels and pressures up to 3500 atm. Effect of high pressure on some chemical reactions is outlined briefly, with particular emphasis on catalytic reactions.

E. G. Chilton, USA

3749. **Eder, F. X., Measurement of the dynamic strength of plastic materials** (in German), *Z. angew. Phys.* **5,** 1, 1–5, Jan. 1953.

Starting from theoretical relations, the importance of experimental conditions in determining the influence of strain rate on the mechanical properties of metals is pointed out. Some interesting and hitherto unpublished experimental results, obtained by author by means of an electromagnetic apparatus in which copper wires were loaded by a brief, strong current impulse, are briefly discussed. The effects of the propagation of plastic waves at high test strain rates (with strain hardening), and of the length of test bar on accuracy of measurement, are considered in the paper. A. D. Topping, USA

3750. **Opinsky, A. J., Thomson, R. F., and Boegehold, A. L., The General Motors research corrosion test: A cyclic humidity accelerated corrosion test for sheet steel,** *ASTM Bull.* no. 187, 47–51, Jan. 1953.

A new type of precision corrosion test has been developed to study the corrosion resistances of bare steel specimens for those applications where the protective rust of specimens exposed on racks outdoors is not fully realized. A slow humidity cycle, an elevated temperature, and a superimposed dip of a weak electrolyte have been so arranged that an almost nonprotective rust is developed after an initial period. There is evidence that this test rates several steels in about the same order as atmospheric exposure testing. The magnitude of corrosion losses of steels exposed to this test is about three times that of the same steels exposed to a modified ASTM salt-spray test (salt concentration 5% by weight) for the same length of time.

From authors' summary

3751. **Wessel, E. T., and Olleman, R. D., Apparatus for tension testing at subatmospheric temperatures,** *ASTM Bull.* no. 187, 56–60, Jan. 1953.

An apparatus for producing tension-testing temperatures from room temperature to −195.6 C is described. Nitrogen vapor is utilized both as the refrigerant and as the testing medium. Predetermined test temperatures are readily obtained and accurately stabilized with an automatic control and recording system. The apparatus is simple and economical to operate and may be adapted to other types of tests. The possibility of testing at even lower temperatures is discussed briefly.

From authors' summary

3752. **McClintock, F. A., Fatigue tests of single crystals of ingot iron,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 653–659, 1952.

Single crystals of ingot iron were tested in a rotating bending fatigue machine in an attempt to correlate orientation crystal with slip surfaces and fatigue cracks. Microscopic examination showed that slip took place in a <111> direction on wavy surfaces which could not be shown to be made up of microscopic facets parallel to certain crystallographic planes. Fatigue cracks usually followed slip surfaces in a stepwise manner; however, the macroscopic orientation of the plane of the crack was parallel to a plane of high stress and probably contained a <111> direction.

J. A. Bennett, USA

3753. **Hartman, A., Peeling tests of light metal sheets.** I (in Dutch), *Nat. LuchtLab. Amsterdam Rap.* M.1893, 24 pp., 13 tables, 14 figs., Jan. 1952.

The mean value and scatter were determined of the peeling strength of redux bonded 24S-T alclad sheet, 0.8-mm thickness, at standard circumstances of the N.A.R.I.

The test used was the Aero Research Ltd., peeling test. The mean value served as a guide in determining the influences of different circumstances during the pretreatment and the bonding process on the quality of the bond. For a redux, a change in peeling strength from 26 to 10 kg was not coupled with any deterioration in shearing strength. Three other metal glues gave low or very low peeling strength. Some tests were made to check the Spies theory of the peeling test; further tests in this direction are advisable.

From author's summary by Ch. Massonnet, Belgium

Mechanical Properties of Specific Materials

(See also Revs. 3677, 3694, 3724, 3733, 3740, 3745, 3746, 3750, 3752, 3753, 3776, 3890)

3754. **Stout, R. D., The preheating and postheating of pressure vessel steels,** *Weld. J.* **32,** 1, 14s–22s, Jan. 1953.

Report is a summary of present knowledge concerning the effects of preheating and postheating operations on the soundness and mechanical properties of welds. An important part of the report is a table containing recommended preheating and postheating temperatures for various carbon contents and thicknesses of the grades of steel commonly used for pressure vessels. A list of problems requiring further study is also included.

From author's summary

3755. **Gross, J. H., Tsang, S., and Stout, R. D., Factors affecting resistance of pressure-vessel steels to repeated overloading,** *Weld. J.* **32,** 1, 23s–30s, Jan. 1953.

The following phases of repeated overloading were studied: (a) Direction of loading: zero to tension vs. reversed bending.

(b) Effect of surface stress raisers. (c) Multibead welds with preheating or postheating. (d) Effect of strength level.
From authors' summary

3756. Tipper, Constance F., Effect of direction of rolling, direction of straining, and ageing on the mechanical properties of a mild steel plate, *J. Iron Steel Inst.* **172,** part 2, 143–148, Oct. 1952.

A series of experiments was carried out on mild-steel plate to determine the effect of plastic strain and aging on notch-impact results and yield point, with the special purpose of investigating directional effects.

Direction of rolling was found to be most significant in Izod-impact tests, the lowering of these values after prestrain being chiefly due to work-hardening and strain-aging. These factors also raised the yield and ultimate tensile stresses and caused loss of ductility.

Direction of straining was found to affect the yield chiefly, both in value and shape. No satisfactory explanation could be found to account for the absence of a recovered yield after aging.
From author's summary

3757. New materials for aircraft. Brief accounts of the properties of new alloys and other materials, *Aircr. Engng.* **25,** 287, p. 25, Jan. 1953.

3758. Edeleanu, C., Transgranular stress corrosion in chromium-nickel stainless steels, *J. Iron Steel Inst.* **173,** part 2, 140–146, Feb. 1953.

The standard grades of austenitic stainless steels have been tested in a magnesium chloride solution. Those in which the austenite does not readily transform on straining have been found to be less susceptible to cracking. Experimental steels have confirmed that such failure can be largely avoided either by increasing the alloy content of the normal steels and thus making the austenite more stable, or by decreasing the alloy content and producing a partly martensitic steel in which the corrosion is less localized and therefore is less likely to cause cracking.

Transgranular stress corrosion has been obtained in many chloride solutions, including some relatively dilute, and there is evidence that oxidizing agents can cause an acceleration.

Metallographic evidence shows that a martensitic phase is produced on straining austenitic steels, and that this phase is corroded preferentially. From author's summary

3759. Kroneis, M., Gattringer, R., and Krainer, H., Relations between kinetics, structure and strength characteristics of chrome-vanadium steel (in German), *Stahl u. Eisen* **73,** 1, 23–30, Jan. 1953.

Authors present extensive data on and analysis of effect of heat treatment on two chrome-vanadium steels. Variables were quenching temperature, cooling rate, annealing temperature, and thickness. Significant improvement of static and notched-bar impact strengths was obtained when steels were quenched from 890 or 920 C. Faster rates of cooling improved static and dynamic properties, as indicated by tests on specimens of varying diameter. Analysis showed that absence of ferrite or pearlite in metal as quenched led to improved physical properties upon annealing. F. J. Mehringer, USA

3760. Franke, E., The influence of impurities on the resistance of aluminum and aluminum alloys to corrosion (in German), *Werkstoffe Korr.* **4,** 1, 4–14, Jan. 1953.

Author gives a compilation of data in the field of corrosion effects on aluminum alloys, especially with respect to the presence of metal and nonmetal impurities. Influence of impurity percentage and distribution, heat treatment, surface condition, and effect of different corrosive media are discussed. The conventional methods for determining corrosion resistance are criticized. A reference index of nearly 100 articles is presented.
R. Nilson, Sweden

3761. Levelton, B., Corrosion in industry, *Engng. J., Montreal* **36,** 1, 8–13, Jan. 1953.

Assessing the potential annual loss to industry through corrosion, author discusses its causes and prevention. Examples are given of the effect of corrosion on typical lumbering and paper-mill equipment. Exposure tests are described and theories given for the causes of failure, from which preventive measures are prescribed. Special attention is given to corrosion from oxygen and salt water. From author's summary

3762. Benkö, A., The influence of alloying elements on the mechanical properties of light metal alloys of the Al-Mg-Si type (in Hungarian), *Hungarian J. Metallurgy—Aluminum* **4,** 5, 97–105, 1952.

The mechanical properties of the Al-Mg-Si-type light-metal alloys as the function of the proportion of the components are described. In respect to the influence of the alloying elements, it was established that, in the event of simultaneous alloying with copper and manganese, higher values of tensile strength and elongation were obtained at all periods of aging than with manganese alone. The presence of copper, however, greatly reduced the corrosion resistance of the composition. Experiments show that 0.2% manganese produces an increase in tensile strength equivalent to 0.65% copper, and best quality of composition is obtained at 0.4 to 0.6% manganese content. Based on economic considerations, it appears that manganese is the most advantageous as the fourth alloying element, since it increases the tensile strength without reducing the corrosion resistance.
Courtesy of Hungarian Technical Abstracts D. Varsányi

3763. Dennison, J. P., and Preece, A., High-temperature oxidation characteristics of a group of oxidation-resistant copper-base alloys, *J. Inst. Metals* **81,** 229–234, 1952/1953.

The influence of small separate additions of aluminum, beryllium, chromium, magnesium, and silicon on the high-temperature oxidation of copper has been examined, these alloying elements having been chosen because their oxides have a high electrical resistivity. The composition and microstructure of the scales formed were studied and correlated with the rates of oxidation.

The effectiveness of the additions in conferring oxidation-resistance was in the decreasing order: beryllium, aluminum, magnesium, silicon, chromium.

Alloys having rates of oxidation less than that of copper showed divergences from the established parabolic and exponential laws. These divergences may be accounted for by a consideration of the relative rates of diffusion of copper and of the alloying element through the oxide layers.
From authors' summary

3764. Voce, E., Copper and copper alloys: a survey of technical progress during 1952, *Metallurgia, Manchr.* **74,** 279, 9–17, Jan. 1953.

Continued progress has been made during the past year in the metallurgy of copper and its alloys. In the various sections of this review, the author discusses the principal items of interest concerning such subjects as raw-material resources, extraction, fabrication, finishing, and properties.
From author's summary

3765. McHargue, C. J., and Hammond, J. P., Preferred orientations in iodide-titanium, *J. Metals* **5,** 1, 57–61, Jan. 1953.

The wire textures for cold-rolled and recrystallized iodide titanium and the sheet textures for this material produced by cold and hot rolling and recrystallization at a series of temperatures were determined. The effect of the $\alpha \rightarrow \beta$ transformation on the sheet texture was noted. From authors' summary

3766. Ihrig, H. K., and Jarman, J. T., The importance of carbon in ferrous metals for engineers, ASME Ann. Meet., New York, Dec. 1952. Paper 52—A-81, 8 pp., 3 tables, 11 figs.

The principal properties of ferrous metals of interest to engineers are largely the result of the amount and type of carbon alloyed with the iron. Experimental work starting with a base iron to which carbon and other alloying elements are added is described. The engineering properties of the various steels produced are compared and related to their alloy content. Carburization and decarburization are discussed. Some of the detrimental effects of carbon in both straight carbon and stainless steels are pointed out.

The effect of both the amount and the form of carbon in cast irons is shown experimentally. The role of carbon in the production of the nodular cast irons, which are new engineering materials with unique properties, is shown.

From authors' summary by T. J. Dolan, USA

3767. Simpkinson, T. V., Behaviour of carbides in niobium stabilised austenitic stainless steel, *Metallurgia, Manchr.* **47,** 279, 18–24, Jan. 1953.

It is shown that in properly processed niobium stabilized 18-8, the carbon is immobilized as a difficultly soluble random precipitate of niobium carbide. How variations in the temperature of final hot-working, in heat treatment, and in welding affect the type and distribution of precipitated carbides seen under the microscope is discussed and illustrated. Improper processing may leave 18-8Nb in a condition of susceptibility to intergranular corrosion. From author's summary

3768. Gillemot, L., The theory of the crystallization of nodular graphite (in Hungarian), *Öntöde* **3,** 2, 25–35, 1952.

The author deals in historic retrospect with the crystallization of nodular graphite. Experiments were conducted to determine the limits of compositions in which nodular graphite is formed and to establish the basic structures in which the graphite appears dependent upon the composition. The results of the tests made on cast irons alloyed with Mg and Ce, respectively, show: (1) After alloying with either Ce or Mg, a part of the nodular graphite separates directly from the liquid; (2) nodular graphite can be crystallized directly from the liquid practically independent of the C and Si contents; (3) in hypereutectic alloys, the remaining part of the graphite forms, due to the decomposition of the cementite. Conclusions are drawn for application in industry.

Courtesy of Hungarian Technical Abstracts I. Balsay

3769. Herzog, R., and Burton, R. H., On the determination of wear characteristics of vulcanized India rubber (in German), *Schweiz. Arch.* **19,** 1, 1–6, Jan. 1953.

3770. Simpson, H. E., Some factors affecting the testing of surface durability of flat glass, *J. Amer. ceram. Soc.* **36,** 4, 143–146, Apr. 1953.

The surface durability of flat glass was studied by subjecting the glass to cycles of surface fogging and clearing. The total transmission and the amount of scattered light of the weathered samples were measured with a photoelectric haze meter, the relative amount of scattering being considered as a measure of the amount of haze or surface deterioration. Some factors influencing the test were considered, especially the age of the samples and previous conditions of storage. Comparisons were made between ground and polished surfaces and fire-polished surfaces. The effects of acid and alkali treatment on the durability of the surfaces were also studied. From author's summary

3771. Johnston, R. D., Chipman, R. D., and Knapp, W. J., Prestressed ceramics as a structural material, *J. Amer. ceram. Soc.* **36,** 4, 121–126, Apr. 1953.

The compressive strengths of most ceramic products are seven to ten times greater than their respective tensile strengths. If ceramic structural members are kept in compression by prestressing, they are capable of carrying much larger loads than members with no prestressing. Through application of the principle of prestressing, tensile stresses are avoided. Results of preliminary experiments with prestressed ceramic members are described. The test findings indicate that prestressing gives marked improvement in resistance to failure in both static and impact loading. Some possibilities are suggested for using prestressing methods with ceramic materials.

From authors' summary

3772. Schulz, E. F., The effect of temperature and composition upon the resilience of elastomers, *ASTM Bull.* no. 186, 56–58, Dec. 1952.

The Bashore resiliometer has been used successfully to measure the resilience of elastomers at temperatures ranging from 0 to 170 C. Such test results are insensitive to sample geometry or finish, are independent of operator effects, and are of good reproducibility. The resilience of elastomers is highly dependent upon temperature. The resilience-vs.-temperature curves for plasticized polyvinyl chloride resins are characterized by pronounced maxima and minima. These curves are dependent upon the composition; they are influenced by plasticizer type and concentration, and by filler content.

From author's summary

Mechanics of Forming and Cutting

(See also Revs. 3730, 3928)

3773. Dawihl, W., and Dinglinger, E., Handbook of carbide tools [Handbuch der Hartmetallwerkzeuge], Berlin, Springer-Verlag, 1953, xv + 237 pp. DM 15.60.

Comprehensive treatment of metallurgy, physical characteristics, manufacturing and use of sintered and cast carbide materials. Properties of metal-cutting tools are evaluated in their interrelationship as well as the effects of cutting forces, cutting temperatures, and tool wear. Details of tool angles and design of single-point tools, also brazing, grinding, lapping of the carbide tips are discussed. Tool life when machining various workpiece materials, surface quality, and depth of deformation in the workpiece as influenced by feed and cutting speed are given in tabular form. Information is supplied on machining of nonmetallic materials like stone, glass, plastics, and laminated wood. Various industrial applications of sintered carbides in Europe, and comparative properties, designations, and compositions of American and British and other European products in relation to those of Germany are listed. Included are standards and proposed standards of carbide tools and tips of various European countries.

A. O. Schmidt, USA

3774. Grodzinski, P., Unorthodox methods of machining hard materials, *Metallurgia, Manchr.* **47,** 279, 34–38, Jan. 1953.

The shaping of very hard materials, such as the sintered tungsten carbides, has given rise to a number of unorthodox machining methods, mainly of an electrical nature. In this article the author reviews the present position, giving references to more detailed published information concerning the methods discussed.

From author's summary

3775. Shaw, M. C., Machinability of metals and tool life (in French), *Rev. Univ. Min.* (9) **9,** 4, 159–195, Apr. 1953.

Paper gives basic considerations of tool angles in general, and those of metal-cutting tools in particular. Theories of formation of chips and supporting evidence from microscopic examinations are stated. Tool life of carbide and HSS tools under identical conditions is compared. Other topics are: Relationship of friction and tool wear; hardness of carbide and HSS tools at various cutting speeds; tool life as determined by wearing away a diamond point impression on flank of tool; effect of various cutting fluids upon HSS tools at different speeds of machining.

A. O. Schmidt, USA

3776. Zlatin, N., Kahles, J. F., and Briggs, C. W., The machinability of cast steels, *Tool Engr.* **30,** 2, 59–67, Feb. 1953.

Article presents machinability data for cast steels that have not been generally available to industrial users of castings.

From authors' summary

3777. Shaw, M. C., Cook, N. H., and Finnie, I., The shear-angle relationship in metal cutting, *Trans. ASME* **75,** 2, 273–283, Feb. 1953.

Authors summarize analytical expressions which have been derived for the shear angle in orthogonal cutting and present a critical review of the assumptions upon which each is based. They introduce the concept that friction between chip and tool is a function of the restraint imposed by cutting conditions upon the metal between the shear zone and the tool face. They conclude that, in the general case, the maximum shear stress is not directed along the shear plane and that the shear angle is given by

$$\phi = 45^\circ + \eta' - \beta + \alpha$$

where η' is the angle between the shear plane and the direction of maximum shear stress, and α and β are the rake and friction angles, respectively. Experimental data are presented in support of their extension of the theory. H. R. Letner, USA

3778. McCormick, T. F., Large extrusion-press operation and production problems in aluminum, *Aero. Engng. Rev.* **12,** 2, 27–33, Feb. 1953.

Author reviews operating techniques and problems associated with present large extrusion presses and indicates some of the expected problems that will arise in production of extruded shapes on presses of 14,000-ton capacity. Paper is one of five describing aspects of the heavy-press program for light metals presented at an ASME symposium. G. Gerard, USA

3779. Papen, G. W., Requirements for large, light-metal forgings and extrusions in the aircraft industry, *Aero. Engng. Rev.* **12,** 1, 24–33, Jan. 1953.

This paper discusses the aircraft-industry requirements for large forgings and extrusions, and supports these requirements by analyzing the effect of the trend in performance on aircraft structure, function, and production. The paper confirms that large integral structural components satisfy these trends better than a continuation of conventional "bits and pieces" structure. It further concludes that large forgings and extrusions are the most economical methods to produce integral-type structure.

In addition, detail requirements of large forgings and extrusions relative to physical properties, tolerance, and refinements are presented.

Statistical studies are presented to indicate the high potential use of large forgings and extrusions.

From author's summary

3780. Kennicott, W. L., Mechanically mounted elements of cemented carbide, ASME Ann. Meet., New York, Dec. 1952. Paper 52—A-62, 14 pp., 16 figs.

Hydraulics; Cavitation; Transport

(See also Revs. 3879, 3940, 3958)

3781. Rouse, H., Cavitation in the mixing zone of a submerged jet (in French and English), *Houille blanche* **8,** 1, 9–19, Jan.-Feb. 1953.

Author experimentally demonstrates a case when incipient cavitation does not occur on the solid boundaries but within the free stream. Turbulent pressure fluctuations can lower the local instantaneous pressure level to cause cavitation in the mixing region of a free jet.

Author emphasizes that the estimates are tentative and experiments are preliminary in nature.

L. S. G. Kovasznay, USA

3782. Longuet-Higgins, M. S., Mass transport in water waves, *Phil. Trans. roy. Soc. Lond.* (*A*) **245,** 903, 535–581, Mar. 1953.

Paper extends general theory of mass transport to include the effects of viscosity. It is shown that the motion in the interior of the fluid depends on the ratio of the wave amplitude a to the thickness of the boundary layer δ; for a^2/δ^2 small, the diffusion of vorticity takes place by viscous "conduction"; for a^2/δ^2 large, by convection with the mass-transport velocity. Appropriate field equations for the stream function of mass transport are derived.

Special attention is given to boundary layers, and a general theory is developed for two types of oscillating boundaries: (1) When the velocities are prescribed at the boundary, and (2) when the stresses are prescribed. The equations of motion can be integrated exactly when the motion is simple-harmonic. A method is given for determining the mass transport throughout the fluid in the presence of an oscillating body, or with an oscillating stress at the boundary. Application of this method is made to the cases of a progressive and a standing wave in water of uniform depth. The solutions differ significantly from the perfect-fluid solutions with irrotational motion. The chief characteristic of the progressive-wave solution is a strong forward velocity near the bottom. The results predicted in this paper agree with those observed in experiments. S. Ostrach, USA

3783. Niemeier, B. A., Seals to minimize leakage at higher pressure, *Trans. ASME* **75,** 3, 369–379, Apr. 1953.

Fixed and moving seals to be used in the super-pressure range, 10,000 to 100,000 psi, as classified by the author, are studied and evaluated. A general discussion of the theoretical problems in confining pressures of great magnitude precedes methods for designing seals for such pressures. A method and device for evaluating seals have been developed to provide confirmation of theories. Practical seal problems and applications are shown.

From author's summary by J. F. Manildi, USA

3784. Hübner, E., On pressure losses of pipes with built-in structures (in German), *Forsch. Geb. Ing.-Wes.* **19**, 1, 1–16, 1953.

Author finds experimentally that the pressure loss of a single bar or of a single grid of bars built in a pipe depends only upon the solidity of the structure and is very accurately predicted by the theoretical method of discontinuity surface in two-dimensional flows, assuming the bar as a sharp-edged plane surface and taking due consideration of the pressure recovery after the flow velocity becomes uniform again. For two and more congruent structures in series, author finds that the contribution of the first structure to the total loss is practically constant and is the same as if it were alone. The contributions of the following ones are approximately equal within themselves and depend only on the ratio of the distance among them to the bar breadth, in case this ratio is greater than about 4. For two structures in series, a minimum of total pressure loss below that of a single structure is observed when the above-mentioned ratio is about 2.

L. S. Dzung, Switzerland

3785. Ezra, A. A., A direct step method for computing water-surface profiles, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 180, 10 pp., Mar. 1953.

The author has a semigraphical method for computing water surface elevations for steady flow in natural channels, taking into account velocity head changes. The pertinent properties of each cross section, including distance to next cross section, are tabulated and plotted against elevation for a given discharge. Profiles are then quickly obtained by graphical means.

V. L. Streeter, USA

3786. Gumensky, D. B., Design of side walls in chutes and spillways, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 175, 7 pp., Feb. 1953.

This work supplies diverse practical formulas enabling quick evaluation of the pressures resulting from special movements of the fluid in hydraulic structures. It studies particularly the case of a stream following a steep slope, the effects of curvature, and the phenomenon of air entrainment. The proposed formulas can be easily used; however, because of the extremely compendious reasoning on which they are based, some reservations seem necessary, as well as a certain carefulness in using them.

L. Escande, France

3787. Bradley, J. N., Rating curves for flow over drum gates, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 169, 18 pp., Feb. 1953.

The need for accurate methods of water measurement in western states is increasing each year. Existing structures serve as convenient meters when their discharge coefficients are known. Author presents drum-gate rating curves for wide range of boundary geometry based on consistent results from eleven models of various sizes. Results are useful for construction of rating curves for prototype structures when coefficient of discharge for one condition is known. Author estimates accuracy of method to approach that of current-meter traverse.

W. DeLapp, USA

3788. Rose, H. E., and Young, P. H., Hydraulic characteristics of packed towers operating under counter-current flow conditions, *Instn. mech. Engrs. Proc.* (*B*) 1B, **4,** 114–126, 1952.

Authors describe study of countercurrent flow of air and water through columns packed with Raschig rings. Results are presented and discussed primarily from the standpoint of effects of three variables—flow rate of water, flow rate of air, and pressure drop across column. Two methods of approach are proposed for solution of practical problems involving countercurrent flow of gas and liquid in packed columns, (a) graphical solution by two- or three-dimensional graphs, and (b) analytical solution by three equations derived and presented by authors. Reviewer considers paper's introduction to be a brief but good résumé of data extant on countercurrent flow in packed columns.

S. R. Faris, USA

3789. Green, R. B., The velocity and thickness of pressure waves in liquids, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 883–886, 1952.

With regard to the importance of pressure waves in certain liquids in the field of hydraulic engineering and design, author derives expressions for velocity and thickness of one-dimensional pressure waves in a continuum.

Derivation is based on the assumption of a Newtonian fluid. This entails consideration of the following properties of the fluid as constant: Coefficient of thermal conductivity, viscosity, specific heat at a constant pressure, and the partial derivatives of specific volume with pressure and temperature. The above assumptions, together with the necessary equations for flow, continuity, momentum, and energy, lead to a third-order differential equation in the variables of specific volume and linear direction of propagation. Satisfaction of this equation at the infinite boundaries of the continuum and at the point of maximum slope in the pressure wave yields the desired solutions.

A numerical example is considered for a pressure wave of 100 atm. The resulting velocity of 1489 m/sec and wave thickness of 0.0014 cm indicate the difficulty in generating such waves, since the wave passes a fixed point in space in 9×10^{-9} sec.

W. W. Berning, USA

3790. Szesztay, K., Simple method for the computation of flood discharges (in Hungarian), *Vizügyi Közlemények* no. 1, 141–144, 1952.

3791. Szebehely, V. G., and Whicker, L. F., Generalization and improvement of the hydraulic analogy, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 893–901, 1952.

The classical hydraulic analogy between free surface water flow in a rectangular channel and two-dimensional gas flow is only qualitative, since the analogy assumes a "hydraulic gas" with an adiabatic constant $\gamma = 2$, instead of the accepted 1.4 for air. In this paper, this analogy is generalized mathematically; the cross section suggested for $\gamma = 2$ is rectangular, for $\gamma = 1.5$ triangular, and for $\gamma = 1.4$ parabolic. The corresponding temperature, pressure, and density relations for the gas flow are derived for general and special cases.

Complete similarity is not achieved since the geometry is different. Results and techniques, using a triangular channel, are presented. A report on base pressure and shock angle measurements is included.

From authors' summary by L. J. Tison, Belgium

3792. Hunter, J. K., and Wilmot, H. F., Flood discharge, *Trans. Fourth Congr. Inter. Comm. Large Dams, New Delhi,* Jan. 1951, in 4 vols., vol. II, 415–452. $48 per set.

The increased importance of flood estimation with regard to dam construction is stated. Common flood formulas (of the type $Q = CA^n$, where A is the area of the drainage basin) are compared and their limited value emphasized. Only the study of records extending at least over 35 to 50 years allows reliable estimation of magnitude and frequency of dangerous floods. Consideration is recommended of different factors such as the intensity, duration,

and extent of rainstorms, the size, shape, and character (natural storage, snow cover, degree of soil saturation) of river catchment area. For three typical rivers—Severn (England), Tansa (Bombay region), and Nile (Africa)—Hazen's probability curves are given and discussed. A short explanation of these useful characteristics, where volume of flood is plotted against average recurrence in years, is included.

O. Maštovsky, Czechoslovakia

3793. Douma, J. H., Hydraulic design of slide, vertical-lift, and tainter gates for high-head reservoir outlets, *Trans. Fourth Congr. Inter. Comm. Large Dams, New Delhi*, Jan. 1951, in 4 vols., vol. II, 349–379. $48 per set.

Model tests conducted on a slide gate at Waterways Experiment Station, and prototype tests at Norfolk Dam, show that, in order to minimize vibration and cavitation when heads exceed 75 ft, slide gates must have 45-deg lips and gate slots must be beveled. Model tests simulating head of 186 ft and prototype tests with 105 ft head showed that vertical-lift gates may be used if the lip is properly beveled.

Model and prototype tests showed that tainter gates can be used in conduits under heads up to 182 ft if conduits are enlarged downstream so as never to flow full, and if proper seals can be developed. Eccentric trunnions and pneumatic rubber seals were used, but seem not to have been entirely satisfactory.

R. W. Powell, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 3668, 3820, 3823, 3829, 3838, 3847, 3904)

3794. Stewartson, K., On the flow between two rotating coaxial disks, *Proc. Camb. phil. Soc.* **49,** part 2, 333–341, Apr. 1953.

The steady motion of a viscous fluid confined between two coaxial rotating disks is discussed both experimentally and theoretically. It is found experimentally that, when the disks rotate in the same sense, the main body of the fluid rotates as well, but, if they rotate in opposite senses, the main body of the fluid is almost at rest. A theory is found to explain this phenomenon.

From author's summary by B. Etkin, Canada

3795. Sowerby, L., and Cooke, J. C., The flow of fluid along corners and edges, *Quart. J. Mech. appl. Math.* **6,** part 1, 50–70, Mar. 1953.

Rayleigh's hypothesis of treating steady flow past a semi-infinite plane with its edge at right angles to the stream by considering the problem of an infinite plate moved suddenly in its own plane with velocity W, and using an appropriate change of variables to replace the time t, is applied. In part I, the steady flow over a circular cylinder is treated, and it is concluded that Rayleigh's hypothesis can be modified by writing $t = \gamma^2 Z/W$ instead of $t = Z/W$ (Z parallel to direction of motion, $\gamma = 1.699$). In part II, the Rayleigh problem for a wedge, i.e., motion of a viscous incompressible fluid bounded by two semi-infinite flat plates intersecting at an angle β, when both plates are set in motion suddenly with a uniform velocity W parallel to their line of intersection, is analyzed in detail. Analysis, which uses Green's function, is analogous to that of heat conduction. Results are applied to estimate drag on a finite rectangular pipe of suitably short length.

M. Morduchow, USA

3796. Yatseyev, V. I., On a class of exact solutions of the equations of motion of a viscous fluid, *NACA TM* 1349, 7 pp., Feb. 1953.

See AMR 4, Rev. 3597 (Yatseev).

3797. Betz, A., The effect of plane flow lattices (in German), *Aerotecnica* **33,** 1, 10–12, Feb. 1953.

Based on Weinig, the deflection of flow by plane cascades is shown in diagrams comparing the circulation with that of a single vane and the change of the tangential velocity component with that of very closely spaced vanes at the same approach speeds.

A. Hollander, USA

3798. Lauer, O., Laminar and turbulent steady-state flow of air and carbon dioxide through a slightly conical tube, in the vicinity of the critical Reynolds number (in German), *Z. angew. Phys.* **5,** 3, 81–90, Mar. 1953.

The behavior of steady flow in the vicinity of the critical Reynolds number in a slightly conical tube is considered. Experiments using air and carbon dioxide are described, and the effect of the Reynolds number, which varies all along the tube, is studied for various configurations. The entropy principle is introduced, and it is shown that for subcritical Reynolds numbers laminar flow should exist, while for supercritical Reynolds numbers turbulent flow must take place on the basis of thermodynamic considerations. Data are plotted defining the value of the critical Reynolds number for the various flow configurations tested.

A. B. Cambel, Canada

3799. Birkhoff, G., Formation of vortex streets, *J. appl. Phys.* **24,** 1, 98–103, Jan. 1953.

It is shown that, for vortex trails in a nonviscous fluid, the mean longitudinal spacing a and mean transverse spacing h are invariant. It follows from this and other known facts that the periodicity of a vortex trail is unstable, not the ratio h/a. In a viscous fluid, a is invariant, but h increases. This fact explains various known experimental observations. A rough explanation is given for the order of magnitude of the Strouhal number S, based on the inertia opposed by the wake to transverse oscillations.

Finally, using the theory of logarithmic potential, it is shown that, even in a nonviscous fluid, the concentration of vorticity is limited to circles whose diameter is about $a/4$.

From author's summary by M. Alperin, USA

3800. Cabannes, H., Analysis of certain characteristic properties of the solutions of the Navier equations (in French), *Bull. Soc. Math. France* **80,** 37–46, 1952.

Author proves that the only three-dimensional flows of a viscous incompressible fluid which are uniform and regular at infinity (i.e., velocity expansible in negative powers of r for large r) must be irrotational and, therefore, potential flows. For plane and axially symmetric flows, he establishes the same result even without the assumption of uniformity at infinity. These results are of interest in delimiting the class of viscous flows that may be considered in flow past a finite body.

Courtesy of Mathematical Reviews D. Gilbarg, USA

Compressible Flow, Gas Dynamics

(See also Revs. 3627, 3663, 3824, 3829, 3832, 3838, 3839, 3840, 3846, 3852, 3855, 3867, 3869, 3877, 3883, 3885)

3801. Eggers, A. J., Jr., and Kraus, S., Approximate calculation of axisymmetric flow near the vertex of a body traveling at high supersonic speeds, *J. aero. Sci.* **20,** 3, 215–217, Mar. 1953.

It is argued that, at the high supersonic speeds considered, the variation of pressure along the family of Mach lines from the body is small and may be neglected. Hence the pressure gradients along the shock and body can be related and hence, making use of

the generalized shock-expansion method, the ratio of shock wave to body curvature at the nose is determined. The results are in acceptable agreement with the more accurate calculations of Shen and Lin. Taylor expansions up to the second order in terms of the radial distance from the axis are then established for the flow direction, pressure, and total pressure along a line extending from body to shock a short distance downstream of the vertex. The coefficients of these expansions are determined from the established conditions along body and shock. The results show good agreement for purely conical flow with the M.I.T. tables.

A. D. Young, England

3802. Ludford, G., Polachek, H., and Seeger, R. J., On unsteady flow of compressible viscous fluids, *J. appl. Phys.* **24, 4,** 490–495, Apr. 1953.

The case of one-dimensional unsteady flow of viscous compressible fluid, far away from the solid surfaces, is treated approximately by replacing the continuum by a system of $N + 2$ particles, moving on a straight line. By considering the particles as subject to the interactions of their immediate neighbors, an equivalent system of dynamical equations is derived with prescribed boundary and initial conditions. As examples, three cases for $N = 99$ for different boundary and initial conditions have been solved numerically. Y. H. Kuo, USA

3803. Tsuji, H., Note on the solution of the unsteady laminar boundary-layer equations, *J. aero. Sci.* **20, 4,** 295–296, Apr. 1953.

Author considers the laminar boundary layer along an insulated semi-infinite flat plate moving in a straight path with an arbitrary time-dependent velocity in a compressible fluid. F. K. Moore has pointed out [AMR **5,** Rev. 828] that the flow depends on nondimensional parameters which are functions of the distance from the leading edge, the velocity of the plate, and its time derivatives. The present author investigates the case in which the velocity of the plate satisfies a certain condition, insuring the reduction of the parameters mentioned above to one. The solution in this case is not worked out; only the equations are written. Three forms of the velocity of the plate are given for which the parameters reduce to one. R. Berker, Turkey

3804. Aronofsky, J. S., and Jenkins, R., Unsteady flow of gas through porous media, one-dimensional case, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 763–771, 1952.

The differential equation of unsteady gas flow through a porous medium is reduced to a difference equation and solved numerically with IBM machines. Time histories of the pressure distribution along the axis of a porous rod are obtained for the case in which one end of the rod is suddenly subjected to a pressure different from that initially in the rod. Rods of infinite and finite lengths are considered, and the pressure distributions for the former case are compared with similar results for flow of liquids through porous media. Gas flow rates are determined by graphical integration of the pressure distributions. A. H. Sacks, USA

3805. Cabannes, H., On the curvature of the attached shock wave at the nose of a body in two-dimensional unsteady flow (in French), *J. rational Mech. Anal.* **2, 2,** 219–232, 1953.

The author considers the problem, first investigated by Crocco [*Aerotecnica* **17,** 519–534, 1937], of the curvature of an attached shock wave at the nose of a curved body. He has sought an explanation of the paradoxical result that, in steady flow for certain body-nose angles, the nose curvature of the shock and the body profile have opposite signs. The case considered here is that of a two-dimensional curved body initially placed in a uniform flow and having an attached shock wave at its nose. The body is then given an angular rotation and the shape of the shock wave is computed at each succeeding instant. In the case of the body at rest, the results obtained by Crocco have been rederived.

In the case of the moving body, it is found that, for certain values of body curvature and angular motion, the nose curvature of the shock does not change sign as the maximum angle for an attached shock is approached. The curvature becomes infinite when the maximum angle is reached.

The method can also be applied to the case of a fixed body placed in a stream of variable speed and constant direction upstream of the nose.

[See also AMR **6,** Rev. 2304.] G. M. Lilley, England

3806. Ludford, G. S. S., The extension to a two-dimensional subsonic flow of the Joukowski force of ideal fluid theory, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 715–721, 1952.

Author uses Rayleigh-Janzen method to prove that the Joukowsky force equations of two-dimensional ideal fluid theory apply also to compressible fluids in the subcritical Mach number range.

H. Lomax, USA

3807. Buseman, A., The nonexistence of transonic potential flow, "Fluid Dynamics," Proc. Symp. appl. Math. vol. IV; New York, McGraw-Hill Book Co., Inc., 29–39, 1953.

Author sketches asymptotic arguments in hodograph plane for nonexistence of regular solutions of transonic potential flows with usual boundary conditions and extreme rarity of triconic "safety valve" existence case. He concludes that "the rising flood of transonic potential flows past large groups of (balanced!) bodies (is) unrealistic and, therefore, deceiving," since the shape of the body portion necessary for balancing excitation initiated by flow following the rest of the body surface cannot be varied, however minutely, without incurring nonexistence of potential flow.

A. Charnes, USA

3808. Vincenti, W. G., and Wagoner, C. B., Transonic flow past a wedge profile with detached bow wave, *NACA Rep.* 1095, 30 pp., 1952.

Supersedes articles reviewed in AMR **4,** Rev. 4530; **5,** Rev. 2106.

3809. Holder, D. W., A note on shock tubes, *Aero. Res. Counc. Lond. curr. Pap.* 110, 11 pp., May 1952, published 1953.

Paper is a digest of information available on the conventional shock tube. It includes an elementary discussion of flow, instrumentation, and design. Description is given of a wide range of problems in fluid dynamics that can be investigated by the use of a shock tube in preference to a wind tunnel.

E. G. Fischer, USA

3810. Burbank, P. B., and Byrne, R. W., The aerodynamic design and calibration of an asymmetric variable Mach number nozzle with a sliding block for the Mach number range 1.27 to 2.75, *NACA TN* 2921, 37 pp., Apr. 1953.

A method of designing an asymmetric, fixed-geometry, variable Mach number nozzle has been developed by using the method of characteristics. A small nozzle conforming to the analytically determined ordinates was constructed and calibrated over a range of Mach numbers extending from 1.27 to 2.75. The results show the variation in Mach number to be ± 0.02 or less and in the flow direction to be $\pm 0.2°$ within the test section. The range of

Mach numbers from 1.27 to 2.75 was obtained by translating the lower block in a straight line parallel to the test-section center line for a distance of 2.17 test-section heights.

From authors' summary

3811. Gadd, G. E., Some aspects of laminar boundary layer separation in compressible flow with no heat transfer to the wall, *Aero. Quart.* **4,** part II, 123–150, Feb. 1953.

If the heat transfer to the wall is neglected, in compressible boundary layers, the parameters which cause most difficulty are σ and ω. $\sigma = \mu c_p/k$ is the Prandtl number, and ω is defined by the relationship $\mu \alpha T^{\omega}$, where T is the absolute temperature. Both are of the order of unity.

The author gives exact solutions for the cases (a) $\sigma = \omega = 1$, and (b) $\sigma = 0$. Feeling that exact solutions for the cases (c) $\sigma = 1$ and $\omega \simeq 1$, and (d) $\sigma \simeq 1$ and $\omega = 1$ are "impossible," he solves them by approximate methods, assuming that the pressure gradient is known.

With the help of the tables given, one can predict the enthalpy distribution and the position of the point of separation, if the pressure gradient is known. But, as the author is aware, the prediction of the gradient is rather difficult, as it depends on shock-wave boundary-layer interactions, and that makes the method practically useless, though interesting in a qualitative manner.

Y. V. G. Acharya, Holland

3812. Zienkiewicz, H. K., A method for calculating pressure distributions on circular arc ogives at zero incidence at supersonic speeds, using the Prandtl-Meyer flow relations, *Aero. Res. Counc. Lond. curr. Pap.* 114, 6 pp., 4 figs., 1953.

Method is based on characteristics pressure distributions calculated by Ehret, Rossow, and Stevens [AMR **4,** Rev. 2602]. It is found that the pressure distribution on circular-arc ogives is related to the distribution on two-dimensional airfoils with the same profile in a very simple way. Thus, with the help of Prandtl-Meyer flow relations, the distributions about bodies of revolution can be calculated very quickly. Method gives very good agreement with characteristics results from other sources and with experimental results. The method can probably be extended to ogives with profiles other than circular arc.

T. Gullstrand, Sweden

3813. Bernard, J.-J., and Siestrunck, R., Kinetic aspects of one-dimensional fluid flow (in French), *Rech. aéro.* no. 31, 45–48, Jan.-Feb. 1953.

Authors consider the kinetic problem connected with a weak shock wave. The distribution function for the molecular velocities is built up from an integral over the ordinary Maxwellian distribution function with temperature as a variable parameter, multiplied by a weight function for this parameter depending on the position in the shock wave. A correction is then sought (of second-order in the velocity difference across the shock wave) by means of Boltzmann's equation, following Chapman and Enskog's method of successive approximations. In the actual calculation, the integral is replaced by a sum over 3 terms of simple structure. The result is given as a differential equation for the mean temperature as a function of the mean velocity of flow.

The paper is written somewhat too briefly to be followed in every detail, and one must guess the meaning of some equations.

J. M. Burgers, Netherlands

3814. Pistolesi, E., Comparison of some methods of supersonic aerodynamics (in Italian), *Aerotecnica* **32,** 5, 242–245, Oct. 1952.

Author's previous study [AMR **4,** Rev. 3632] of plane distributions of steady supersonic singularities suggested that use of doublet distributions in wing calculations may sometimes be invalid, by contrast with correct results obtained from vortex distributions. Present paper's attempts to calculate velocity on delta (reversed delta) wing with uniform lift distribution and subsonic leading (trailing) edges by doublet and by vortex distributions yield inconsistent results, explicitly showing nonequivalence in general. Author derives sufficient conditions elsewhere [*Atti Accad. naz. Lincei R. C. Sci. Fis. Mat. Nat.* **13,** 205–210, Nov. 1952] for equivalence of doublet and vortex potentials.

J. H. Giese, USA

3815. Sasaki, T., On the solution of transonic flow using Laplace transformation, *J. phys. Soc. Japan* **7,** 6, 625–626, Nov.-Dec. 1952.

The brief note makes use of the Laplace transformation in the hodograph method to arrive at a solution for transonic flow. The usual difficulty of analytic continuation across singularities in the hodograph method is avoided. Author gives some simple solution approximate to the order of q^2/q^2_m (square of the ratio of the local velocity to ultimate velocity). However, the method is no more simpler nor easier than the ordinary hodograph method as far as higher-order approximation is concerned. To the order of q^2/q^2_m, the transonic flow past a nearly circular cylinder is given at free-stream Mach number = 0.4 as an illustration.

C.-C. Chang, USA

3816. Dubois, Geneviève, Contribution to the experimental analysis of high-speed gas flow by small perturbation methods within the domain of ultrasonics (in French), *Publ. sci. tech. Min. Air, Paris* no. 269, 55 pp., 1952.

Comprehensive experimental and theoretical studies are reported on the feasibility of using ultrasonic waves of known frequency introduced into a gas stream to determine absolute velocity and static temperature of the gas. The great advantage of the method is the absence of material probes in the flow so that results are obtained with negligible disturbance of the flow field.

Three types of generators for ultrasonic waves were investigated: Piezo quartz oscillator, magnetostrictive oscillator, and Hartmann generator, a mechanical sound source.

It was found that only the Hartmann generator approaches the requirements of a high-intensity sound field because of its great transmission efficiency. Because of small transmission efficiency of the two other generators, amplitudes of the oscillators would be necessary which exceed the strength of the quartz crystals and lead to very high temperatures of the magnetostrictive generator.

With the Hartmann generator, wind-tunnel flow was investigated by sound fields perpendicular and parallel to the flow. In the first case, the generator was built into the tunnel wall; in the second case, on the center line of the tunnel in the subsonic part of the tunnel upstream of the throat. In neither case was it possible to observe the ultrasonic waves at supersonic Mach numbers. In the subsonic range there was little difficulty in observing the sound waves up to a Mach number of about 0.6. By reducing the frequency of the ultrasonic waves from 57,000 cps to 22,000 cycles, the sound field was visible up to a Mach number of near 1, and the determination of this Mach number from the wave length of the sound was in fair agreement with measurements simultaneously conducted with a Pitot tube.

The main difficulty of the method lies in the fact that high ultrasonic frequencies are necessary in order to obtain sufficiently low wave lengths for accurate local measurements. However, the absorption of the sound increases with the sound frequency. Thus, it becomes very difficult to avoid complete absorption or, at least, disappearances of sound waves in the turbulence of the flow.

In an effort to observe the waves in the supersonic range, it was successfully tried to penetrate shock waves of small shock intensity by the sound waves.

Reviewer agrees with author's conclusion that method may have some valuable applications; however, the difficulties in obtaining good results are considerable. Paper shows well the limits of the method and covers briefly almost anything which has to be considered, including the special requirements for the schlieren system. Several schlieren pictures of the sound fields are shown.

Reviewer conducted almost identical studies during the war and arrived at the same limits of the method. Especially the use of the Hartmann generator and the arrangement of the generator on the center line of the tunnel were also found to be the most favorable arrangement. Reviewer could show then that, for the available flow Mach numbers up to 4.3, sound waves of at least a great portion of the audible range could be transmitted into the supersonic section of the tunnel through the throat and penetrated the shock wave in front of the receiving microphone, which was placed in the supersonic section. These studies have been described briefly in Wright-Patterson Air Force Base report IRE-61, April 24, 1946, under the title, "Measurement of temperature of air flow with sonic waves." H. J. Ramm, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 3669, 3781, 3798, 3803, 3811, 3839, 3901, 3951)

3817. Drake, R. M., Jr., Calculation method for three-dimensional rotationally symmetrical laminar boundary layers with arbitrary free-stream velocity and arbitrary wall-temperature variation, *J. aero. Sci.* **20,** 309–316, May 1953.

Mangler transformation is applied to reduce problem to one of two-dimensional flow. Use is then made of Hartree's solutions of the momentum equation for power-law variation of speed with meridional distance from stagnation point and Levy's solution of the energy equation for similar variation of temperature to obtain approximate solutions for three-dimensional case with arbitrary variation of free-stream velocity and wall temperature. Results are compared with computations of Scholkemeier for the general case and with Homann's exact solution for stagnation-point flow. H. L. Dryden, USA

3818. Kirkby, S., and Nonweiler, T., The numerical solution of certain differential equations occurring in Crocco's theory of the laminar boundary layer, *Coll. Aero. Cranfield Rep.* no. 74, 9 pp., May 1953.

A relaxation procedure is described for the solution of a pair of differential equations which arise from the application of Crocco's transformation to the laminar boundary-layer equations at hypersonic speeds.

From authors' summary by E. B. Klunker, USA

3819. Chandrasekhar, S., Some aspects of the statistical theory of turbulence, "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV, New York, McGraw-Hill Book Co., Inc., 1–17, 1953.

Author reviews some of the mathematical aspects of the theory of homogeneous turbulence and gives a clear account of the contributions he has made in the past few years. The topics considered are (a) the invariant theory of isotropic tensors and of axisymmetric tensors, (b) the extensions to the formal equations of turbulence that are needed when magnetic fields are present, and (c) density fluctuations in isotropic turbulence.

G. K. Batchelor, England

3820. Torda, T. P., Ackermann, W. O., and Burnett, H. R., Symmetric turbulent mixing of two parallel streams, *J. appl. Mech.* **20,** 1, 63–71, Mar. 1953.

Turbulent, incompressible, symmetric mixing of two parallel streams is studied. The influence of the upstream boundary layers on the mixing process is taken into account. The von Kármán integral concept is applied to a momentum and energy equation to evaluate the thickness of the mixing region and the velocity distribution in it. Results are presented in nondimensional form, and a numerical illustrative example is given. Comparison is made with Tollmien's analytical results and with experimental data for Liepmann and Laufer.

From authors' summary by S. Ostrach, USA

3821. Iglisch, R., Elementary existence proof for the laminar boundary flow of the potential flow $U = u_1 x^m$ with $m > 0$, in case of suction and exhaust (in German), *ZAMM* **33,** 4, 143–147, Apr. 1953.

Existence of solutions of the well-known differential equation $f''' + ff'' + \beta(1 - f'^2)$ with the boundary conditions $f(0) = C$; $f'(0) = 0$; $f'(\infty) = 1$ for $\eta = 0$ and additively: $f'(\eta) > 0$ for $0 < \eta < \infty$ has been shown in the special case of $\beta = 1$ and for all C by author in 1943. $C > 0$ means herein suction, $C < 0$ blowing out. This paper proves the existence for $\beta > 0$ and arbitrary values of C. F. W. Riegels, Germany

3822. Rotta, J., On the theory of the turbulent boundary layer, *NACA TM* 1344, 50 pp., Feb. 1953.

See AMR **3,** Rev. 2729.

3823. Emslie, K., Hosking, L., and Marshall, W. S. D., Some experiments on the flow in the boundary layer of a 45° sweptback untapered wing of aspect ratio 4, *Coll. Aero. Cranfield Rep.* no. 69, 13 pp., Feb. 1953.

Visual methods have been used together with a yawmeter to illustrate conditions of flow in the boundary layer over a sweptback wing. It was found that at moderate incidences a marked outflow in the boundary layer was developed. At higher incidences (about 16°), what appears to be laminar separation with reattachment occurred at the leading edge near the root; this manifests itself as a standing vortex. At a somewhat lower incidence (12°), a region of separated flow in the turbulent boundary layer developed at the trailing edge. The extent of this region was found to increase with increase of incidence. Boundary-layer thickness was found to increase rapidly toward the trailing edge, and slightly as the tip was approached. When the angle of outflow became equal to the angle of sweepback (i.e., the chordwise flow was on the point of separation), the spanwise boundary-layer profiles showed marked deviation from the $^1/_7$th power law, but at lower incidences the spanwise flow profiles approximately followed this law. From authors' summary by P. Eisenberg, USA

3824. Krzywoblocki, M. Z. v., On the generalized fundamental equations of isotropic turbulence in compressible fluids and in hypersonics, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 827–835, 1952.

Starting with equations of motion, continuity, state, and energy and assuming that all random variables are isotropic and homogeneous, author derives three generalized fundamental equations for the propagation of the velocity, temperature, and pressure correlation functions, respectively. Several relationships between linear, bilinear, and trilinear forms in these equations are also deduced. For flow at higher Mach numbers where the Navier-Stokes equations do not apply, author starts from kinetic theory of nonuniform gases to evaluate additional terms

in the equations of motion and energy. The additional correlation terms are calculated and included in the fundamental equations.

From author's summary by W. D. Baines, Canada

3825. Stanitz, J. D., Aerodynamic design of efficient two-dimensional channels, *Trans. ASME* **75,** 7, 1241–1255, Oct. 1953.

A general design method is presented for two-dimensional channels with arbitrary prescribed velocity distributions along the channel walls. The design method is developed for compressible or incompressible fluids and is applied to the design of channels with relatively thin boundary layers. Maximum deceleration rates that avoid turbulent boundary-layer separation are discussed, and it is shown that linear variations in a certain velocity parameter along the channel walls give a suitable engineering approximation to the velocity distribution resulting from boundary-layer considerations. For these linear variations in velocity parameter the design method is rapid.

Eleven numerical examples are presented for compressible and incompressible flow in elbows and diffusers. In addition, some experimental results are presented which show that, provided the initial boundary layer is sufficiently thin, efficient two-dimensional channels can be designed for prescribed velocity distributions that avoid boundary-layer separation.

From author's summary by J. R. Stalder, USA

3826. Scholz, N., On a rational calculation of the drag of slender bodies with surfaces of arbitrary roughness (in German), *Jahrbuch Schiffbautechn. Gesellschaft* **45,** 244–263, 1951.

This is an extension of the known procedures for calculation of turbulent boundary layers without pressure gradient to cases where there is pressure gradient. The body surface may be hydraulically smooth or rough. The starting point is still the momentum equation. For both the hydraulically smooth surface (at the high Reynolds numbers) and the rough surface, the universal logarithmic velocity distribution laws from pipe flows are borrowed. The local shearing stress is taken to depend upon the local values of the free-stream velocity, momentum thickness, and roughness, in the same way as a flat plate without pressure gradient. Finally, a power law to fit the logarithmic velocity distribution in the boundary layer throughout the length of the body is chosen in a certain average sense. The momentum equation can then be integrated in closed form exactly like the case without pressure gradient. Calculation of separation point is based on Gruschwitz's criterion. A similar development of bodies of revolution is carried out. Examples are calculated, including two NACA profiles, each in three thicknesses, both as two-dimensional surfaces and as bodies of revolution. From a comparison of the drag coefficients, the thickness effect turns out to be much stronger than the chordwise velocity distribution. S. F. Shen, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 3687, 3801, 3808, 3810, 3859, 3877, 3910, 3911, 3914, 3921, 3923)

3827. Fung, Y. C., Statistical aspects of dynamic loads, *J. aero. Sci.* **20,** 5, 317–330, May 1953.

Because of the random nature of the dynamic loads on aircraft structures, a detailed analysis of structural response to a specific forcing function is of doubtful value. Paper presents as an alternative a statistical approach to the problem. Measured load data are analyzed on a statistical basis and presented in the form of probability curves. The dynamic response of the structure is similarly treated statistically. By this means, an "envelope" of the most probable largest stress at any point in the structure can be found. By the use of such probability data for maximum stress, the life expectancy of an aircraft can be determined as a function of the specified load intensity, or vice versa.

Paper presents the basic statistical theory required. Application to simplified versions of the airplane gust- and landing-load problems is illustrated. Approach is interesting and promising, but the degree of complexity involved in a more complete treatment of the pertinent problems remains to be seen.

G. Isakson, USA

3828. Katzoff, S., Faison, F., and Dubose, H. C., Determination of mean camber surfaces for wings having uniform chordwise loading and arbitrary spanwise loading in subsonic flow, *NACA TN* 2908, 43 pp., May 1953.

Authors reduce problem of computing slope of mean camber surface to the evaluation of a line integral around the planform of the wing. The acceleration potential is used. Calculation of the mean camber surfaces for several cases involving triangular and sweptback wings is presented. Method is claimed to be superior to previous methods [see *NACA Rep.* 826] because it is readily adapted for use on high-speed computing machines.

R. C. Roberts, USA

3829. Kuessner, H. G., A review of the two-dimensional problem of unsteady lifting surface theory during the last thirty years, Inst. Fluid Dynamics and appl. Math., Univ. of Maryland, Lecture Ser. no. 23, 22 pp., Apr. 1953.

The theoretical work done during the past thirty years on the two-dimensional unsteady flow around lifting airfoil is reviewed. The problem is presented in a simple and generally valid way. The solutions reached by various authors for incompressible and compressible flows are shown. The manner in which these solutions are presented and proved is very elegant.

G. V. R. Rao, USA

3830. Holme, O., and Hjelte, F., On the calculation of the pressure distribution on three-dimensional wings at zero incidence in incompressible flow, *Roy. Inst. Technol. Stockholm, KTH Aero TN* 23, 28 pp., 1953.

Authors calculate perturbation potential and streamwise perturbation velocity produced by a distribution of sources, with intensity proportional to local slope, over wing surface. Exact integrations are obtained for rectangular wing with constant-thickness parabolic arc profile and for triangular planform with linearly decreasing-thickness parabolic arc sections. Results are used for comparison of the numerical integration of $\int_S \int \psi(\xi,\eta) f(x-\xi, y-\eta) d\xi d\eta$. Numerical procedure consists of subdividing S into small elements over which a mean value for source intensity function ψ may be taken, multiplying by the quadrature of the distance function f, and summing over all elements. Region containing singularity in f is isolated, and contribution to double integral evaluated. Singularities in ψ are not considered (blunt-nosed profiles not considered). Methods presented for obtaining mean value of ψ are: Values at equidistant points, average value over element, expansion in series. Distance matrixes for use with these methods are given, and mechanical technique for manual computation is described. Procedure is satisfactory for points not in vicinity of planform boundaries. Numerical results, using average values for ψ, are in good agreement with exact integrations.

E. Lapin, USA

3831. Jacobs, W., A simplified procedure for the calculation of the induced sidewash of airplanes (in German), *Ing.-Arch.* 21, 1, 23–32, 1953.

In a preceding paper with E. Truckenbrodt [AMR 6, Rev.

3162], a rather unwieldy solution for the sidewash field induced by antisymmetric spanwise loadings of a straight wing was given. Here, the spanwise distribution of the circulation $\gamma_\beta(\eta)$ is assumed known, and a rapid procedure for approximate calculation of the corresponding sidewash at standard tail locations (i.e., sufficiently far downstream to drop the streamwise x variable) is set up. Six polynomials $f_n(\eta)$ vanishing at tip and midspan are used as "influence functions," i.e., any distribution $\gamma_\beta(\eta)$ is approximated by $\sum_1^6 K_n f_n(\eta)$, but the criterion for best choice of the coefficients K_n is not given. The contributions to the sidewash field at any point of the Trefftz plane corresponding to each distribution $f_n(\eta)$ having been computed once for all and plotted in Figs. 3–8, the final result follows by numerical superposition. Figures illustrating the application of the procedure to the case of unit yaw of a high wing airplane (fuselage effect) and to cases of half-span and full-span ailerons are shown.

M. V. Morkovin, USA

3832. Flax, A. H., Reverse-flow and variational theorems for lifting surfaces in nonstationary compressible flow, *J. aero. Sci.* 20, 2, 120–126, Feb. 1953.

See AMR 5, Rev. 2666.

3833. Beane, Beverly, Influence functions for computing lift and rolling moment of a twisted narrow delta wing, *J. aero. Sci.* **20, 2,** 138–140, Feb. 1953.

See AMR 6, Rev. 1693.

3834. Rogallo, V. L., and McCloud, J. L., III, Calculations of upwash in the region above or below the wing-chord planes of swept-back wing-fuselage-nacelle combinations, *NACA TN* 2894, 15 pp., Feb. 1953.

For the purpose of estimating propeller vibratory stresses, the upflow angle distribution at the horizontal center line of the propeller disk is calculated. No interference between wing, nacelle, and fuselage is taken into account, so that the induced flow is simply calculated as the sum of the flows induced by wing, nacelle, and fuselage separately. For the determination of the induced velocity field, the wing is replaced by a lifting line and the fuselage by an infinite long cylinder.

Measurements of upflow angles are done with six semispan models with 40° sweptback wings. The agreement between the vertical and experimental results is satisfactory for use in estimating propeller vibratory stresses. H. G. Loos, USA

3835. Mathews, C. W., and Kurbjun, M. C., An analysis of the factors affecting the loss in lift and shift in aerodynamic center produced by the distortion of a swept wing under aerodynamic load, *NACA TN* 2901, 65 pp., Mar. 1953.

The major simplifications in the analysis are as follows: The wing structure is assumed to be a shell which has constant spanwise stress under a uniformly distributed load. The swept wing is replaced by an unswept wing in bending deflection computations. Angle-of-attack changes resulting from bending deflections are computed for a uniformly distributed aerodynamic loading.

The magnitude of the errors introduced by these simplifications is discussed.

The results show that large variations in the aeroelastic effects associated with wing bending are produced by changes in aspect ratio, sweep angle, and thickness ratio. The effects of wing flexibility on the longitudinal stability of an airplane become more important relative to considerations of wing stress as the aspect ratio or sweepback angle is increased or the thickness ratio decreased. G. E. Nitzberg, USA

3836. Dorsch, R. G., and Brun, R. J., A method for determining cloud-droplet impingement on swept wings, *NACA TN* 2931, 29 pp., Apr. 1953.

Report presents the generalized equations of motion for a water drop moving in three-dimensional inviscid flow. These equations then are adapted to computing water-drop trajectories about a swept wing. Results indicate that the area, rate, and distribution of water-drop impingement on a swept wing can be determined simply from two-dimensional trajectory data calculated for a plane airfoil section. The only requirements for making the conversion are: (1) The two-dimensional trajectory data must be for a wing section which is geometrically similar to the one in the normal plane of the swept wing being considered; and (2) the dimensionless parameters used to define values of area, rate, and distribution of impingement, and which normally are referred to the free-stream plane, now must be referred to the normal plane of the swept wing. The authors' finding increases the utility of two-dimensional trajectory data.

N. R. Bergrun, USA

3837. Brun, R. J., Gallagher, Helen M., and Vogt, Dorothea E., Impingement of water droplets on NACA 65_1-208 and 65_1-212 airfoils at 4° angle of attack, *NACA TN* 2952, 49 pp., May 1953.

Report is part of a comprehensive research program which is concerned with an appraisal of the problem of ice prevention on high-speed aircraft. Principal variables involved and their ranges investigated are as follows: droplet diam, 5–100 microns; airplane speed, 150 mph to critical flight speed; altitude, 1000 to 35,000 ft; chord length, 2 to 20 ft.

Starting with the differential equations of motion of a droplet in a two-dimensional flow field, the droplet trajectories are determined with respect to the airfoil. The incompressible-flow field about the airfoil is determined by a vortex substitution method and the calculations are carried out with the aid of electronic computors.

From the known droplet trajectories, the amount of water impinging on the airfoils, the area of impingement, as well as the rate of impingement per unit area on the airfoil surface are determined for the various conditions cited above.

For similar conditions of operation, the NACA 65_1-212 collects more water than the NACA 65_1-208 airfoil. The extent of impingement on the upper surface of the 65_1-208 airfoil is considerably less than on the upper surface of the 65_1-212 airfoil, while on the lower surfaces of both airfoils the extent of impingement is about the same. C. E. Carver, Jr., USA

3838. Allen, D. N. de G, and Dennis, S. C. R., The application of relaxation methods to the solution of differential equations in three dimensions. II. Potential flow round aerofoils, *Quart. J. Mech. appl. Math.* **6,** part 1, 81–100, Mar. 1953.

Use of the velocity potential in two and three dimensions requires satisfaction of boundary gradient condition. The region is made simply connected by a cut along the wake whose position is initially unknown. The condition of equal pressures on either side of the wake renders a criterion for its correct position.

Problems actually solved, with computation schemes given, are two-dimensional thin airfoil, rectangular thin wing of aspect ratio 4, and sweptback wing of aspect ratio 3. Comparison with known results is given. J. R. M. Radok, Australia

3839. von Kármán, T., On the foundations of high speed aerodynamics, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 673–685, 1952.

This paper is an abridged version of the author's contribution to vol. V of the series, "Jet propulsion and high-speed aerody-

namics." With his well-known talent for clear exposition, the author examines a field in which he himself has made fundamental contributions. The subheadings are: Incompressible flow; propagation of pressure; supersonic vs. subsonic flow; linearized theory of supersonic flow; finite disturbances in compressible flow, shock waves; the hypersonic range; transonic range; entropy and vorticity; entropy rise and drag; the role of viscosity; limitations of the theory of continuous fluids; aerothermodynamic problems of combustion.

L. M. Milne-Thomson, England

3840. El Badrawy, R. M., Two-dimensional airfoil cascades at supersonic speeds (in German), *Mitt. Inst. Aerodyn., ETH, Zürich* no. 19, 90 pp., 1952.

Two-dimensional lift and wave-drag coefficients of a thin flat plate are computed, tabulated, and graphed for purely supersonic flow, i.e., when the Mach number past the oblique shock remains supersonic. Linearized theory is compared with th exact method (shock-wave theory and Prandtl-Meyer expansion). A cascade of flat plates is treated next, a linearized theory is established and then compared with remarkable schlieren pictures of two staggered profiles of 0.05 to 0.07-mm leading-edge thickness. Nonstationary flow with small changes in angle of incidence is discussed, based on linearized potential theory of distributed sources [AMR **3**, Rev. 98], and extended to cascades without stagger. Velocity, pressure, and moment distribution as functions of time are given for a numerical example. The efficiency of a supersonic propeller is estimated by extension of the cascade method to include finite thickness and friction. G. R. Graetzer, USA

3841. Solomon, W., Aerodynamic characteristics of a two-blade NACA 10-(3)(062)-045 propeller and of a two-blade NACA 10-(3)(08)-045 propeller, *NACA TN* 2881, 53 pp., Jan. 1953.

3842. Meyer, J. R., Jr., and Falabella, G., Jr., An investigation of the experimental aerodynamic loading on a model helicopter rotor blade, *NACA TN* 2953, 110 pp., May 1953.

Pressure distributions were measured on a model helicopter rotor blade in hovering and simulated forward flight. Pressures were recorded for a range of advance ratios from 0.10 to 0.50 for zero-offset flapping-hinge rotor, and from 0.10 to 1.0 with 13% offset. Two advance ratios in each condition ($\mu = 0.22$ and 0.50 for zero offset, $\mu = 0.22$ and 1.0 for 13% offset) were fully analyzed. The recorded data for other (nonanalyzed) μ's are also included.

In analyzing aerodynamic loads of rotor blades, assumptions are often made which reflect rather a need for mathematical simplicity than physical reality of occurring phenomena. In this situation, any attempt to get a clearer insight into actual mechanics of air reacting on the blades is of prime importance to a theoretical research worker, as well as to a practical engineer. In reviewer's opinion, this paper represents an important contribution to the art by presenting this direct insight into mechanics of aerodynamic rotor loading. Because of this directness of measurements and because of the wide range of advance ratios investigated at two values of flapping-hinge offset, this work is highly recommended to all those interested in the theoretical as well as the practical aspect of rotor aerodynamics.

W. Z. Stepniewski, USA

3843. Trebble, W. J. G., and Holford, J. F., Low speed wind tunnel investigation of tab hinge moment characteristics, *Aero. Res. Counc. Lond. curr. Pap.* 112, 7 pp., 4 tables, 9 figs., Nov. 1951, published 1953.

Test results are given for a $^1/_2$-span model of a horizontal tail surface of symmetrical section equipped with a 50% chord elevator with a full span 5% tab. Tab results are compared with empirical theory of *Rep. Mem.* 2730, which accounts for the presence of airfoil boundary layer. Results agree well with empirical theory and show that even at full-scale Reynolds numbers, hinge moment due to tab deflection is only 70% of nonviscous theoretical value for small deflections. At large deflections, results agree well with nonviscous theory. Hence, nonlinear characteristics must occur. H. J. Allen, USA

3844. McBride, E. E., and Fisher, L. J., Experimental investigation of the effect of rear-fuselage shape on ditching behavior, *NACA TN* 2929, 35 pp., Apr. 1953.

Model tests were made to isolate specific effect of shape of rear fuselage on ditching behavior, because this is the part which usually hits water first when an airplane is ditched. Basic fuselage was a streamlined body of revolution, with variation of longitudinal curvature, cross section, fineness ratio, and landing speeds. Behavior was recorded by high-speed motion-picture camera. Results are presented in graphs and tables, with recommendations as to best shapes under various circumstances.

C. W. Smith, USA

3845. Oliver, A. L., The low speed performance of a helicopter, *Aero. Res. Counc. Lond. curr. Pap.* 122, 7 pp., 5 figs., May 1952, published 1953.

The analysis and estimation of helicopter performance are dependent upon the accurate assessment of rotor-induced velocity. An empirical curve relating the flow through the rotor to the flight speed is used for vertical flight, and the momentum theory is sufficiently accurate for a tip-speed ratio greater than about 0.1, but no simple method has been generally available for the intermediary speed range.

Sets of empirical curves covering this speed range and based on the analysis of low-speed flight performance are given. The charts give values of the rotor-induced velocity varying smoothly from the vertical-flight state to the forward-flight region in which the momentum theory becomes accurate. The charts are presented in forms suitable for determining steady flight performance and also for estimating rotor thrust during accelerated motion in, for example, take-off flight.

From author's summary

3846. Carpenter, P. J., Effects of compressibility on the performance of two full-scale helicopter rotors, *NACA Rep.* 1078, 8 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 2168.

3847. Jones, W. P., The calculation of aerodynamic derivative coefficients for wings of any plan form in non-uniform motion, *Aero. Res. Counc. Lond. Rep. Mem.* 2470, 12 pp., Dec. 1946, published 1952.

Author's vortex-sheet method for calculating aerodynamic forces on lifting surfaces of general shape in unsteady motion [British *ARC Rep. Mems.* 2026, 2117, 2145] is simplified by extending Falkner's method [*Rep. Mem.* 1910] for approximate calculation of downwash distributions to unsteady flow. Method involves replacement of continuous chordwise distributions of vorticity by discrete vortexes giving the same two-dimensional downwash at selected control points. Essential feature of extension to unsteady flow is development of similar method for taking account of vorticity in wake. Existing tables of downwash due to rectangular vortex filaments, set up for the Falkner method, can be used to facilitate part of the computations. The downwash due to wake vorticity is found to depend in part on a

generalization of Cicala's integral. A short table of this integral for nonoscillatory, exponentially subsiding motions is given, values of this integral for harmonic motion being available in the literature.

Author suggests that, since the Falkner method gives satisfactory solutions to many steady-flow problems, method of this paper might well prove to be satisfactory for unsteady-flow problems. Other methods of approximately evaluating the downwash due to wake vorticity for high-aspect-ratio wings, based on the methods of Cicala [*NACA TM* 887, 1939] and Reissner [*NACA TN* 946, 1944], are discussed briefly.

A. H. Flax, USA

3848. Falkner, V. M., The scope and accuracy of vortex lattice theory, *Aero. Res. Counc. Lond. Rep. Mem.* 2740, 30 pp., Oct. 1949, published 1952.

An outline of development of principles of vortex lattice method for computing downwash is given. Conditions of convergence necessary for an accurate solution are defined. It is shown that these conditions can easily be satisfied. Report is a combination of previous work [*ARC* no. 9621] of the author. The study of accuracy is now advanced by a comparison based on exact values calculated from surface integrals given by W. P. Jones and applied to a rectangular and a sweptback wing. The downwashes obtained from the lattice are shown to converge to the exact values. By a comparison of two solutions for the sweptback wing, it appears that it is unnecessary to obtain individual downwashes to great accuracy, at least for spanwise load grading and aerodynamic center calculations.

From author's summary by A. van Heemert, Holland

3849. Michael, W. H., Jr., Analysis of the effects of wing interference on the tail contributions to the rolling derivatives, *NACA Rep.* 1086, 12 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 3963.

3850. DeYoung, J., Theoretical symmetric span loading due to flap deflection for wings of arbitrary plan form at subsonic speeds, *NACA Rep.* 1071, 41 pp., 1952.

Method of numerical computation for symmetrical span loadings according to the Weissinger theory [*NACA TM* 1120], previously given by author and C. W. Harper [*NACA TR* 921], is extended to include swept wings with flaps. Flap deflection is considered to be equivalent to change in local geometric angle of attack, as is usual in lifting-line theory. It is claimed that this concept is valid for aspect ratios above 2. Since, in basic method, boundary conditions are satisfied at only seven control points along span, special treatment is required for discontinuity in angle of attack due to flap. Approximate method is devised based on author's exact solution [*NACA TN* 2011] for flapped wing of zero aspect ratio. Effective geometric angle of attack at each control point is calculated so as to give correct section lift at all control points on the wing of zero aspect ratio having the same flap arrangement as the actual wing. These effective angles of attack are then used in the author's basic method for determining the load distribution.

Tables and curves to facilitate application of the method to practical problems are given. Correlation of theoretical values of $C_{L\delta}$ with experiment for 17 wings of various planforms shows agreement within 10% for most of the higher aspect ratios and within 20% for all cases shown. A. H. Flax, USA

3851. Littlewood, W., Technical trends in air transport, *J. aero. Sci.* **20**, 4, 225–279, Apr. 1953.

Paper is 16th Wright Brothers lecture of the Institute of the Aeronautical Sciences. It presents a review of experience and observations on air transport engineering from point of view of the airline engineer. Author covers power plants, propellers, ice protection, landing gears, structures, performance, crash survival, noise, operation, possible future transports, and numerous other subjects. H. Luskin, USA

3852. Bull, G. V., Comments on the aerodynamics of low aspect ratio wing-body-tail combinations in steady supersonic flow, Univ. Toronto, Inst. Aerophys., 40 pp., Dec. 1952.

This paper is essentially a collection and discussion of the works of others applicable to the calculation of missile aerodynamic characteristics. It is perhaps best summarized in the words of the author: "Some basic theoretical methods applicable to missile configurations are reviewed and applied to configurations employing rectangular planform panels arranged in cruciform. Assuming no interference between body and panel, the pressure distribution for a thin, flat, rectangular panel is used to compute the chordwise element of lift, the panel lift coefficient slope, the spanwise center of pressure, and panel aileron power. The results obtained by Beskin for a body of revolution in supersonic flow are reviewed, and the cruciform wing-body problem is considered by discussing the effect of the body on the panels, the effect of the panels on the body, and the effect of one cruciform panel on the other. The wing-tail interference problem is discussed and some results presented. A brief discussion of viscous effects, skin temperatures, and elastic deformations is included."

A. J. Eggers, Jr., USA

3853. Hošek, J., Effect of small variations in airplane characteristic data on its performance, *Engng. Rev., Prague* no. 7, 15–34, Feb. 1951.

3854. Hošek, J., Tolerances for airplane rates-of-climb, climbing times and ceilings, *Engng. Rev., Prague* no. 7, 35–41, Apr. 1951.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 3847, 3879)

3855. Ruppel, W., and Weber, R., Flutter analysis in the supersonic range (in French), *ZAMP* **4**, 2, 128–145, 1953.

A systematic method of calculating the elements of the flutter determinant for swept wings, based on two-dimensional theory applied to sections rigid chordwise, is presented in some detail. The method lends itself to digital mechanization.

C. M. Ablow, USA

3856. Broglio, L., On the calculation of the critical velocities of wings (in Italian), *Aerotecnica* **33**, 1, 13–26, Feb. 1953.

Critical flutter velocity of a wing depends largely on its lowest frequencies of free torsional vibrations. These frequencies and the critical flight velocity for torsional divergence of wings are given as characteristic numbers (eigenvalues) of a differential equation of the type

$$d[B(x)\cdot d\vartheta/dx]/dx + \omega^2\cdot j(x)\cdot\vartheta = 0$$

which can be easily transformed into a more simple nondimensional form. The end conditions for cantilever wings are: $\vartheta = 0$ for $x = 0$, and $d\vartheta/dx = 0$ for $x = a$; but the same equation with other end conditions is of practical importance in other fields of engineering.

The maximum and minimum basic frequencies of $2r - 1$ parts

of the original wing form the upper and lower boundaries for eigenvalues of order r of the whole wing. Close approximations for these values can be obtained if well-known equation for the sum of the n-th powers of the reciprocal eigenvalues from the theory of integral equations is used to divide the wing in appropriate sections and to derive new inequalities of greater precision. Special expressions of greater accuracy but of a somewhat restricted validity are given for the lower boundaries of eigenvalues. The division of the wing may be preferably carried on graphically. In a numerical example, upper and lower boundaries for frequencies of free torsional vibrations and for critical divergence speed of a wing are calculated with an accuracy from 2 to 4%. A. Kuhelj, Yugoslavia

3857. Reissner, E., A problem of the theory of oscillating airfoils, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 923–925, 1952.

Author presents an approximate solution for the aerodynamic forces on an airfoil of infinite span, which is derived from his previous work for the case of finite span. A table shows the effects of aspect ratio and reduced frequency on these forces.

B. Smilg, USA

3858. Schwartz, M. D., On the application of station functions to the transient aeroelastic problems, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 917–922, 1952.

It is shown that application of the station-function technique to the transient aeroelastic problem leads to a method of determining the aeroelastic response characteristics by a minimum of calculations. Since the true physical system is dealt with directly, the results obtained present the same information as would be obtained by flight tests.

The simplified illustrative example indicates that it is possible to compare experimental and theoretical results directly. It is demonstrated that rigid-body degrees of freedom, wings of arbitrary planform, or rigidly or elastically mounted wing masses can be introduced into the problem without undue complication.

From author's summary by V. P. Zimnoch, USA

3859. Stewart, W., Higher harmonics of flapping on the helicopter rotor, *Aero. Res. Counc. Lond. curr. Pap.* 121, 16 pp., Mar. 1952, published 1953.

The theory and methods of determining the amplitudes of flapping harmonics of a helicopter rotor blade up to the sixth order are presented. The calculations for a straight, rigid blade are given as solutions of a system of simultaneous algebraic equations of Clapeyron type. This paper is a valuable contribution to the literature on helicopter rotor analysis. Its main shortcoming is the limitation of a rigid blade and its neglect of blade stall considerations, but it does lead the way for expansion of work on the subject. R. A. Young, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 3655, 3662, 3797, 3841, 3886, 3891, 3896, 3898, 3922)

3860. Theodorsen, T., Theory of propellers, "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 109–116, 1953.

Summary of the vortex theory of propellers is given in a simple form. The terms axial loss and mass coefficient are explained. It is shown how ideal efficiency, thrust, and torque can be determined by graphical analysis, making use of the tables of the circulation functions given in the author's book ["Theory of propellers," McGraw-Hill Book Co., Inc., New York]. Tietjens has recently used a similar method for the determination of the optimum efficiency of a type of ship propellers whose blade characteristics are known as a function of several parameters [AMR 6, Rev. 2387]. The reviewer has also calculated the ideal efficiency of propellers on similar lines, in a paper which is to be published shortly, and agrees with the author that the method of graphical analysis using the circulation distribution is simpler than pure theoretical analysis and is sufficiently accurate.

Y. V. G. Acharya, Holland

3861. Wells, R. J., and Crocker, B. E., Sound radiation patterns of gas turbine exhaust stacks, *J. acoust. Soc. Amer.* 25, 3, 433–437, May 1953.

Sound radiation in an engine test cell is calculated by assuming a uniform plane source at the stack opening and as measured by a rectangular band analyzing instrument. A circular stack is found to be more effective in beaming the high-frequency sound upward than a square stack. Case of uniform pressure but random phase distribution at source is also treated for square stack. Agreement with experiment is reasonably satisfactory.

L. S. Dzung, Switzerland

3862. Speer, E. E., Design and development of a broad-range, high-efficiency centrifugal compressor for a small gas-turbine-compressor unit, *Trans. ASME* **75,** 3, 395–404, Apr. 1953.

Operating characteristics of the compressor of a small gas-turbine compressor which produces all of its useful output in compressed air are discussed. Design conditions include high efficiency over a wide flow range, with rising head as delivered flow is reduced for pulsation-free operation at low flows.

The presented analysis shows a 30° to 35° backward-curved impeller would produce the design conditions.

Test results are presented for a two-stage compressor with a double-suction first stage and single-suction second stage. In a unit of envelope, dimensions of 16-in. diam by 13.5-in. length, at 1710 rpm, an adiabatic efficiency of 81.2%, a compression ratio of 3.36, and a flow rate of 2.5 lb per sec of standard inlet air were obtained. H. W. Iversen, USA

3863. Betz, A., On the calculation of cascade flow at fairly great distances between the blades (in German), *ZAMM* **33,** 4, 113–116, Apr. 1953.

The singularity method for calculating the flow around airfoils in cascade was developed by the author in 1931. The fundamental idea of this method consists in replacing the airfoils in cascade either by single vortexes or by continuous distributions of vortexes. The flow around each airfoil will then be found by the superposition of three flows: (1) The flow which is not being disturbed by the airfoil in cascade ("mean flow"); (2) the flow which is induced by the airfoil in question; (3) the flow which is induced by the remaining airfoils. By application of sources and sinks one can also take into consideration the shape (thickness) of the airfoils.

The calculations following this method can generally be executed only by a graphical integration. In this case both principal tasks—(a) calculation of the shape of the airfoils, and (b) study of the effect of any existing airfoils in cascade—can be solved with any sufficient exactness. [See, e.g., APM 462, 1952.]

In this paper, the author considers infinitely thin airfoils in cascade. The third of the above-mentioned flows is represented by a series development. Only the first term need be used when there are sufficiently great distances between the airfoils in cas-

cade. The consideration of a certain distribution of vorticity $\gamma(l)$ along the airfoil's length l is reduced to turning moments and moments of inertia of the distribution of vorticity. This means a considerable abridgment of the calculational work, and sufficient exactness will be obtained for large distances between the airfoils in cascade. M. Strscheletzky, Germany

3864. Sen, S., Some aspects of constant reaction axial flow compressor design, *J. Instn. Engr. (India)* **32, 3, 105–119, Mar. 1952.**

3865. Ghoneim, M. M., Measurements of heat transfer and of volumetric efficiency on an air compressor (in German), *Mitt. Inst. Thermodyn. Verbrennungsmotor., ETH Zürich* no. 11, 53 pp., 1952.

Author measured heat-transfer coefficient and its effect on a volumetric efficiency of a specially built reciprocating compressor at various compression ratios, piston speeds, and clearance volumes. Heat transfer was found to increase only slightly with increasing piston speed but decreased markedly with increasing clearance volume. Compression ratio did not seem to affect heat transfer.

Reviewer misses a more systematic and quantitative evaluation of the test results. Some elementary theoretical developments are in error. For example, the heat flow was taken as the integration of TdS, although the state change within the compressor cylinder was far from being quasistatic. At another place, the terms $-p_2V_2 + p_1V_1 + {}_1\int^2 pdV$ were said to cancel, while evidently they add up to $-{}_1\int^2 Vdp$.

L. S. Dzung, Switzerland

3866. Pennington, R., Centrifugal pumps in steam power stations, *Instn. mech. Engrs. Proc. (B)* **1B, 4, 129–140, 1952.**

Condenser-circulating, condensate-extraction, and boiler-feed centrifugal-pump applications are discussed in terms of the depression head. Depression head is defined as the drop in pressure between the pump inlet flange and the region of lowest pressure in the impeller inlet. Empirical relations of the specific speed, capacity, and limiting depression head to prevent cavitation are shown for standard pump-design practice.

Author includes discussion of condensate system operation with free-level and controlled-level condensers; boiler-feed pump operation with constant-speed and variable-speed drive, stability in parallel operation, and fluid temperature rise in the pump at reduced pump loads; and relative economy of high-temperature pump compared to high-pressure heater boiler-feed systems.

Development of the depression-head relationships contains errors in argument, although the final form is correct. Author omits comparisons with other published information on operation limits of centrifugal pumps due to cavitation. Analysis of the fluid temperature rise in a pump, and of the relative merits of the different boiler-feed systems are in error due to neglect of compressibility influences. H. W. Iversen, USA

3867. Fraenkel, L. E., Some curves for use in calculations of the performance of conical centrebody intakes at supersonic speeds and at full mass flow, *Aero. Res. Counc. Lond. curr. Pap.* **108, 6 pp., 27 pp. of figs., Dec. 1951, published 1953.**

The following parameters useful in the calculation of the performance of single conical center-body intakes are presented in graphical form: (1) Shock wave inclination angle, (2) pre-entry, or additive drag coefficient, (3) full mass-flow ratio, and (4) conical flow variables of flow direction, Mach number, and pressure coefficient.

A range of free-stream Mach numbers from 1.3 to 3.0 is considered with semicone angles of 15, 20, 22.5, 25, 30 deg. The material is taken directly from tabulated conical-flow solutions for $\gamma = 1.405$. The variation of the parameters with γ is briefly indicated. R. W. Bower, USA

3868. Lausetti, A., Logarithmic charts for the efficiency characteristics of turboreactors (in Italian), Conv. Stud. Propul. Reaz., Milano, Apr. 1952, 33–37; *Suppl. Ric. sci.* **22, 5, 1952.**

In turboreactor techniques, the diagrams of specific consumption as a function of the thrust at a given number of revolutions and at various heights are well known as a means of representing their use characteristics. Nevertheless, in order to obtain a complete picture of turboreactor efficiency, it is necessary to make use of several diagrams, one for each rotation rating of the turbine-compressor group.

The author points out that, by means of logarithmic scales, it is possible to sum up in one single diagram all the characteristics of turboreactors which are of interest to the plane designer, and he presents one of these diagrams as an example.

From author's summary

3869. Panetti, M., General investigation of the problem of jet propulsion (in Italian), Conv. Stud. Propul. Reaz., Milano, Apr. 1952, 3–18; *Suppl. Ric. sci.* **22, 5, 1952.**

The general character of the work cycle of the turbojet engines and the calculation of the final state of the turbine in view of the changes in its degree of reaction are stated at the beginning. Then author deals with the problem of similarity between flights at various heights and deduces the relation between the thrust and the specific consumption at similar rates.

These rules are confirmed by comparison of the De Havilland diagrams for the Goblin-35 turbojet engines.

The advantages of direction variators of the shovels at rates different from those indicated in the draft are also mentioned.

From author's summary

3870. Majorca, S., Short note on new testing techniques of the Fiat Company for the experimental analysis of turbojets (in Italian), Conv. Stud. Propul. Reaz., Milano, Apr. 1952, 67–74; *Suppl. Ric. sci.* **22, 5, 1952.**

Here are briefly described the test apparatuses that lately have been developed by Aviation Engines Experience Center of Fiat (Sangone). These apparatuses include equipments for measuring the quantity of air drawn and fuel consumed by a jet engine operating on the test bench; an "automatic observer" for recording in flight the operation data of the engine and of the airframe; a special bench for ground testing and measuring the static thrust of the engine fitted to the aircraft; and, finally, an apparatus for testing the jet impellers at overspeed.

From author's summary

Flow and Flight Test Techniques

(See also Revs. 3843, 3844, 3870, 3902, 3903)

3871. Straub, L. G., Killen, J. M., and Lamb, O. P., Velocity measurements of air-water mixtures, *Proc. Amer. Soc. civ. Engrs.* **79, Separ. no. 193, 14 pp., May 1953.**

Paper discusses a meter for measuring velocities in air-water mixtures. The meter marks a small element of a flowing mixture and then records the time this marked element traverses a fixed distance. The marking is done by injecting a very small amount of salt solution or similar electrical conductor into the stream. The passage of this ionized cloudlet is detected by electrodes at

fixed stations in the flow path. These electrodes are connected to an electronic circuit and a cathode-ray tube. Information is given as to the practicality of operation, the effectiveness and the accuracy of the meter. R. C. Binder, USA

3872. Mignolet, J. C. P., Simple and multiple gas microintroductors for adsorption studies, *J. sci. Instrum.* **30,** 1, 15–17, Jan. 1953.

An improved microintroductor is described which enables measured volumes of gas from 0.2–50 mm^3 or more to be introduced into an apparatus at a low pressure. Several microintroductors can be combined together with an important reduction in complication. These simple and multiple microintroductors, using the mercury cutoff principle throughout, allow very pure gases to be handled without risk of contamination. They are well adapted for adsorption studies on evaporated films.

From author's summary

3873. Borden, A., Shelton, G. L., Jr., and Ball, W. E., Jr., An electrolytic tank developed for obtaining velocity and pressure distributions about hydrodynamic forms, *David W. Taylor Mod. Basin Rep.* 824, 35 pp., Apr. 1953.

The design and development of an electrolytic tank are described and a discussion is given of some of the difficulties encountered in putting the tank into operation. The techniques developed for finding the velocity and pressure distributions about cylindrical bodies and about three-dimensional bodies of revolution are described, and some results obtained for bodies with known velocity and pressure distributions are presented.

From authors' summary

3874. Mielenz, K.-D., and Schönheit, E., On the theory of quartz filament manometer (in German), *Z. angew. Phys.* **5,** 3, 90–94, Mar. 1953.

Author solves filament equation of motion for small harmonic oscillations and low gas pressures. The damping effect by the gas, which is proportional to the pressure, is ascribed to both velocity components of the gas molecules, perpendicular to the filament. Maxwell-Boltzmann's velocity distribution is assumed to remain valid and the molecules to be perfectly elastically reflected. The derived value for $t_{1/2}$ agrees with existing one-filament experimental data. It is shown that it is not permissible to neglect the velocity component perpendicular to the direction of oscillation. Data of two-filament meters, some of them presented by author, show more damping than predicted by one-filament theory, probably due to the unavoidable thickening at the junction of the two filaments. Yap Kie Jan, Holland

3875. Honnell, P. M., Anomalous transient response of a crystal pick-up, *J. acoust. Soc. Amer.* **25,** 3, 570–574, May 1953.

An account of experimental investigation into spurious, high-frequency components in the transient response signal from a Brush BL-301 crystal vibration pickup. A cissoidal calibration of the pickup indicates that the anomalous character of the transient response is the result of multiple resonances of the flexure member. Experiments also indicate that the sensitivity of the device is increased when the flexure member is mass loaded.

E. J. Martin, Jr., USA

3876. van de Vooren, A. I., Theory of the Erdmann interferometer for investigation of compressible flows, *Appl. sci. Res.* (*B*) **3,** 1, 18–28, 1953.

Interferometry discussed is of the field absorption type, proposed by S. F. Erdmann [AMR **4,** Rev. 4595], where the camera takes a picture of the optical inhomogeneity in the light of a partially masked diffraction image of the illuminating (monochromatic) source. Local intensity of illumination at screen is represented by an integral in whose integrand the phase differences due to the geometry and the optical inhomogeneity appear superimposed. Paper improves theory of fringe formation by retaining coordinate-dependence of former to within linear approximation in the integrand, rather than eliminating it by an averaging procedure, as done in earlier studies. Resulting formulas are numerically evaluated to construct illumination intensity on screen for rectangular objects of uniform optical density gradient, the diffraction image being masked by an infinite slit normal to the density gradient. Improved agreement with observed qualitative features is claimed. F. J. Weyl, USA

3877. Love, E. S., and Grigsby, C. E., A new shadowgraph technique for the observation for conical flow phenomena in supersonic flow and preliminary results obtained for a triangular wing, *NACA TN* 2950, 16 pp., May 1953.

Authors' new technique permits the study of supersonic flow around a conical or triangular wing structure in a plane nearly normal to the axis of propagation. A conical light field with the light source located near the front of the model and close to the apex of the flow field is superimposed on the conical or almost conical flow field and is projected on a screen downstream of the model to give a shadowgraph. Either a point light source inside the tunnel or an external light source with an appropriate optical system is used. To prevent choking of the tunnel by the projection screen, it is not a solid disk but a rectangular flat metal strip which is made to rotate like a propeller in a plane normal to the flow direction. The camera is located at an appropriate angle outside the tunnel. The shadowgraphs presented for different flow conditions around a triangular wing suggest that the method has interesting possibilities for shock-wave investigations.

Ruth N. Weltmann, USA

3878. Baines, W. D., and Smith, I. D., A continuous recording point gauge for the measurement of surface waves, *Nat. Res. Counc. Canad. mech. Engng. Rep.* no. MH-38, 15 pp., 6 figs., Mar. 1953.

Device was developed as means for studying unsteady flow in river models and consists of sensing and telemetering components; paper describes only the sensing element. Sensing element is a solenoid-driven vertical probe with platinum tip, with simple thyratron circuit regulating solenoid action. Sensitivity is determined largely by mechanical constants of the system, including mass, dashpot damping value, and surface tension height. Units described measure the water-surface elevation to 0.001 ft and will respond to level changes of 0.15 in $^1/_{10}$ sec.

J. H. Carr, USA

3879. Murrow, H. N., and Payne, C. B., Flight investigation of the effect of transient wing response on wing strains of a four-engine bomber airplane in rough air, *NACA TN* 2951, 24 pp., May 1953.

Report presents results of flight measurements of strain amplification effect in wing due to dynamic response under gust loads. In a plot of ratio of wing-strain-in-gust to wing-strain-in-steady 1-g pull-up vs. average acceleration measured at two nodes of the wing first symmetrical bending mode, the slope of fitted straight line is defined as amplification factor (*A-F*). Test results show *A-F* varies along half-span, being slightly higher at root end (near root, 1.31; near tip, 1.27). Calculations are alleged to show, for consideration of first bending mode only that, inboard, *A-F* is 1.34, while near tip *A-F* is 0.99 for a 5-chord-to-peak sine gust. Meas-

urements show minor effect on A-F of 13% mass increase and 40% speed increase. Mass increase confined to wing made an estimated 7% reduction in frequency of wing first symmetrical bending mode. Tests show about 19% reduction in A-F for increase in time to peak nodal acceleration from 0.1 sec to 0.6 sec. Wing twist appears to have minor effect compared to estimated angle-of-attack change, due to low amplitude and highly alternating character of twist during much slower angle-of-attack change. Shear strain measurements are too irregular to be satisfactorily definitive at all but most outboard stations.

P. R. Hardesty, USA

3880. Clark, A. B. J., and Harris, F. T., with an appendix by Roberson, R. E., Free-flight air-drag measurement techniques, *J. aero. Sci.* **19, 6, 385–390, June 1952.**

Using a conventionally suspended ballistic pendulum with a period of 3.2 sec, data have been secured for determining the air-drag coefficient C_D for cal 0.50 spheres in the region of Mach numbers 1.4 to 5.4. Pendulums having seismographic suspensions with periods from 17.5 to 30 sec were also used in securing some of the above data. When corrections for end effects were made, the values for C_D were in close agreement with results by other methods. The ballistic pendulum method is applicable to the determination of air-drag coefficients of small projectiles when suitably designed baffle holes are used. J. E. Brock, USA

3881. Khalil, K. H., Wind tunnel investigations on rotating blades of aerofoil section, *Instn. mech. Engrs. Proc.* (*A*) **166,** 4, 419–426, 1952.

See AMR 6, Rev. 1043.

3882. Schlichting, H., Report on the special field "Interference" to the wind-tunnel committee in Febuary 1945, *NACA TM* 1347, 46 pp., May 1953.

Contains an outline of investigations dealing with interference effects on the static stability of various airplane configurations that had been conducted, were being conducted, and were started at the time of this present report. Results of several investigations are presented and discussed briefly. A supplement is attached showing the configurations tested and outlining the various test programs. Suggestions for future investigations are also included.

From author's summary by R. M. Crane, USA

3883. Fallis, W. B., Johnston, G. W., Lee, J. D., Tucker, N. B., and Wade, J. H., Design and calibration of the Institute of Aerophysics 16 in. × 16 in. supersonic wind tunnel, *Univ. Toronto, Inst. Aerophys. Rep.* no. 15, 91 pp., Mar. 1953.

The design and construction features of the Institute of Aerophysics 16-in. × 16-in. supersonic wind tunnel are described. It operates as an intermittent, atmosphere-to-vacuum blowdown tunnel by utilizing the pressure differential which exists between a large dry air chamber and a 40-ft-diam vacuum sphere. The running time over the working Mach number range is about 20 sec or longer.

Performance curves are presented for sphere evacuation, pressure recovery, and tunnel running time.

The calibration results for the mahogany nozzle blocks at $M_1 = 1.56$ and $M_1 = 2.48$ are given in detail. The Mach number distribution compares favorably with other supersonic wind tunnels.

From authors' summary

3884. Haneman, V. S., Rauch, L. L., Leite, R. J., and Cotecchia, U. A., Automatic reduction of wind-tunnel data, *Aero. Engng. Rev.* **12,** 2, 42–47, Feb. 1953.

An analog computer has been developed to eliminate the present costly time-consuming process of manual data reduction. This computer will take the output of transducers, operate on them, correct for tares, position, etc., and produce a d-c voltage proportional to the desired quantities of their coefficients. The main features include: Immediate computation and presentation of results; ability to follow dynamic phenomena up to 500 cps; an accuracy at least as high as the average transducer; self-balancing and checking of various components; calculation of a "least squares" fitting to test data; ability to integrate pressure data over a model for force; and low-cost construction.

From authors' summary

Thermodynamics

(See also Revs. 3657, 3748, 3813, 3948, 3953, 3961)

3885. Hearth, D. P., and Perchonok, E., Analysis of heat addition in a convergent-divergent nozzle, *NACA TN* 2938, 18 pp., Apr. 1953.

A flow analysis is made for a convergent-divergent nozzle wherein the effect of heat addition to the divergent stream is related to the variation of exit Mach number, static pressure, total pressure, and jet thrust. The analysis was based on the assumption that the flow was one-dimensional, inviscid; the working fluid a perfect gas with a constant ratio of specific heats. The convergent expansion was considered to be isentropic, whereas the divergent expansion was characterized by heat addition (due to delayed combustion processes, for example) in such a way as to yield a power-function variation of total temperature with the cross-sectional area of the flow. The results indicate for increasing heat addition: (1) An increase in thrust; (2) a decrease in exit Mach number; (3) an increase in exit static pressure; and (4) a decrease in exit total pressure. It was further indicated that overexpansion of a convergent-divergent nozzle might be reduced by addition of heat in the divergent section.

R. M. Drake, Jr., USA

3886. Hamrick, J. T., and Beede, W. L., Some investigations with wet compression, *Trans. ASME* **75,** 3, 409–418, Apr. 1953.

Paper presents the results of some experimental investigations on several centrifugal-flow compressors using water injection. In addition, mechanical considerations, special instrumentation, and theoretical aspects are discussed and a method of computing adiabatic efficiency with wet compression is presented.

From authors' summary

3887. Heller, L., Fighting the war on irreversible loss of energy (in German), *Acta Techn. Hung., Budapest* **6,** 3–4, 263–309, 1953.

Author pleads for judging efficiency in heat engineering in terms of increases in entropy rather than in terms of a balance of work and heat, so that attention is automatically focused on possibilities of improvement. This proposition is illustrated by discussing the best use of cooling water which is supplied by two sources of different temperature, the throttling of steam, and other examples. R. Eisenschitz, England

3888. Machlin, E. S., Some applications of the thermodynamic theory of irreversible processes to physical metallurgy, *J. Metals* **5,** 3, 437–445, Mar. 1953.

The basic postulate states that an irreversible process proceeds at a rate which is proportional to the magnitude of the decrease in free energy, provided that the magnitude is sufficiently small.

This postulate usually covers the processes which occur at the surfaces of growing crystals or grains within metals. Theoretically, the rate of growth of a crystal is a function of its size. Observed rates of crystal growth are usually limiting values as determined for crystals too large to exhibit size effects. The induction effect is ascribed to slow growth of submicroscopic crystals rather than delayed initiation of the crystallization process. The theoretical effect on growth rate of impurities which travel with grain boundaries is consistent with some experimental observations. The disappearance of submicroscopic crystals is explained. J. D. Bush, USA

3889. **Netz, H., Prevention of corrosion by means of fume-dispersion installations** (in German), *Werkstoffe Korr.* **4**, 1, 2–4, Jan. 1953.

Paper presents some ideas on the accelerated corrosive destruction of metal members in humid localities. Simple methods of fume dispersion are discussed from the thermodynamical point of view. R. Nilson, Sweden

3890. **Ször, P., Data on the thermoelastic behavior of rubber** (in Hungarian), *Magyar Tudományos Akad. Kémiai Osztályának Közleményei* **1**, 3–4, 79–90, 1952.

A comparison is made of the thermodynamic formulas concerning elasticity of rubber deduced by Elliot and Lippmann on the one hand, and by G. Gee and G. M. Bartenev on the other. A conclusion was reached that no essential difference exists between the two, except that the evaluation of the Bartenev formula gives a more general picture of the thermic behavior of rubber. Measurements were made to prove the validity of the equations in case of compression, and it has been ascertained that intrinsic energy does not change up to a 20% compression and the Bartenev equation holds good up to the same compression. In the course of experiments, the value of β has been determined from the change of the elasticity constant with the change in temperature. It has been shown that in the event of compression also the modulus increases linearly with absolute temperature.
Courtesy of Hungarian Technical Abstracts I. Finály

3891. **Robinson, S. T., The closed-cycle gas-turbine power plant,** ASME Ann. Meet., New York, Dec. 1952. Paper no. 52—A-137, 24 pp., 18 figs.

After a short review of the development of the closed-cycle plant up to the present, the thermodynamical basis of the cycle is explained. The special advantages with regard to turbomachinery size and part-load efficiency are stressed. The special problems related to the heat-transfer equipment are treated in detail, as are also various constructional questions.
E. Haenni, Switzerland

3892. **Bailey, N. P., Energy flow and conversion,** ASME Ann. Meet., New York, Dec. 1952. Paper no. 52—A-54, 19 pp.

Author states that total energy flow rate (power) of a gas when flowing from one region to another should be determined by adding the rates of flow of the following: (1) Internal energy, (2) kinetic energy, (3) transmitted energy. The first two terms are defined as usual in physics or thermodynamics. Transmitted energy rate is defined as the product of static pressure, area, and velocity. When this term is rewritten, as weight rate of flow times pressure times specific volume, and added to the first term their sum is rate of flow of total enthalpy. This shows the above equation to be equivalent to the usual equation of energy rate for gas flow.

The author states that pressure is a result of the surrounding gas and not a true measure of energy stored in the gas itself, and hence the term enthalpy is not necessarily constant when flow is being created. He further states, "This transmitted energy, as previously discussed, is supplied either by the power unit or by the internal energy of the stationary surrounding atmosphere, depending on operating conditions.

"Such an energy balance cannot be arrived at by using wind-tunnel superposition and conventional methods of handling the energy equation. Superposition results in leaving all the energy in the air stream regardless of the supposed output of the jet engine. There appear to be good and sufficient reasons to call for a re-examination of present methods.

"Most fluid-mechanics books of the past 15 years do not so much as mention the fact that superposition is being used, let alone point out that velocity superposition is invalid in the study of energy changes."

When the method is applied to the analysis of the thrust force on the jet engine, for both free flight and thrust conditions, the reviewer finds that the resultant equations are similar to those developed by conventional methods. However, the author concludes as follows: "(1) The formation of flow in a gas at rest in space is a process which is not described by the conventional energy equation of thermodynamics. (2) The concept of enthalpy is not a pure property of a medium, since it also involves an implied process. For that reason, transmitted energy and internal energy should be carried as separate terms in the general energy flow equation. (3) In the study of flow, velocity superposition is invalid for the study of energy changes. The flow of an initially moving gas about a stationary object is not the energy equivalent of the flow that forms in a stationary gas as an object moves through it. For that reason, velocity superposition should not be used in the analysis of such processes as jet-engine cycles."
A. S. Andes, USA

3893. **Kihara, T., and Hirschfelder, J. O., Schematic theory of flame propagation,** *Univ. Wisc., Nav. Res. Lab.*, CM-766, 19 pp., Feb. 1953.

The propagation velocity of one-dimensional steady flames sustained by a unimolecular or a bimolecular reaction has been treated theoretically by means of an idealized model of the reaction rate and under some simplifying assumptions.
From authors' summary

3894. **Barret, P., Temperature and thermal equilibrium in a diffusion flame** (in French), *Publ. sci. tech. Min. Air Paris* no. 273, 114 pp., 1952.

Paper describes research to determine if thermal equilibrium exists between gas and carbon particles in diffusion flames of acetylene in air.

Theoretical study of application of line reversal method to illuminating flames is made. Author concludes that coincidence of temperatures of gas as measured by sodium-line reversal method and of particles as measured by Kurlbaum method is criterion of uniformity of temperature as well as of thermal equilibrium. Kurlbaum method is an optical method which essentially determines what brightness of reference source is not modified by interposition of flame between source and an optical pyrometer.

Experimental study yielded the following results: For thin flames, agreement between the two temperatures was reasonably good. For cylindrical flames at lower flow rates, agreement was poor except where two temperatures could be measured at a local point. For incandescent flames, this is possible only at outer surface of flame. Experimental results coupled with theory suggest thermal equilibrium exists but temperature is not uniform.

Author concludes that classical optical methods alone are not

sufficient to investigate distribution of temperature in incandescent flames. Only in the case where uniformity of temperature has been verified can methods utilizing radiation of particles accurately represent the temperature of gas volume considered.

Reviewer finds experimental section in paper unusually complete, with good bibliography. A useful paper for workers in the field. Marjorie W. Evans, USA

3895. Osborne, F. E., High temperature propellent reactions, *Aircr. Engng.* **24,** 279, 134–137, May 1952.

A method is presented for determining the concentrations of the gaseous products resulting from any CHON-type propellant reaction. Tabulated values are presented of the enthalpy and entropy of the constituents for the temperature range, 2800 to 3400 K. Values are also shown for the equilibrium constants for the pertinent chemical reactions. Thermodynamic equilibrium and perfect-gas behavior are assumed throughout.

J. H. Childs, USA

3896. Ruegg, F. W., and Klug, H. J., Analytical and experimental studies with idealized gas turbine combustors, *J. Res. nat. Bur. Stands.* **49,** 5, 279–298, Nov. 1952.

Problems of flow, heat release, and mixing in gas-turbine combustion chambers are discussed and analyzed. The analysis is based on an ideal or equivalent chamber in which the end result is the same as in the conventional chamber, but in which the functions are separate and distinct. A large primary zone is advantageous, but the combustion process still is burdened by an inverse relationship between primary air and fuel. Conditions favorable to combustion in the primary zone over the whole range of operation are realized by means of a mechanical control. Agreement between analysis and experiment was demonstrated by tests of a chamber with a mechanical control. Comparison of the field of mixing of primary flame gas and secondary air with other studies of mixing revealed a general similarity but a slower rate of mixing that is ascribed to the effects of a large difference of temperature or density in these experiments.

From authors' summary

It should be noted that there is no guarantee of high combustion efficiency at all operating conditions, freedom from carbon, or wide stable operating conditions by following the above design criteria.

The authors have attempted a simple analysis of a turbine engine combustor and have succeeded in this attempt to a limited degree. The reader, however, may be misled in the thought that a combustor designed by the methods employed should give good results. It should be pointed out that there are a number of design criteria that a good chamber should have, but these do not guarantee low pressure drop, high combustion efficiency at all operating conditions, freedom from carbonization, or a wide range of stable operation.

The idea of a mechanical control to keep a constant full-air ratio near stoichiometric conditions in the primary zone is a good one and has been tried experimentally with some success, but the actual installation in an engine would be difficult mechanically.

The chemical reaction kinetics have been ignored in the article to keep the analysis simple, but it is known that the reaction rate increases at a rate greater than linear when combustor size is increased. Gaseous fuel also simplifies the analysis, but since vaporizers are still being perfected, the problems of fuel, fuel volatility, and nozzle design are still problems.

Another point which may affect the analysis is the present trend toward compressors which handle large amounts of air at present compressor sizes. This means that in order to prevent an increase in combustor size and thus increase the aerodynamic drag, the velocity through the combustor inlet must be much higher than the authors considered, particularly at high Mach numbers. High compression ratios would have some effect on reducing the inlet velocity, but it will still be high.

Analyses of this type must be made to give a general picture of some of the phenomena which occur, but no one has yet predicted or designed a combustor from theory; it is still very much a cut-and-try solution, using general criteria such as found in this article for basic design. A. W. Jones, USA

3897. Holmes, V. V., Pahnke, A. J., Uyehara, O. A., and Myers, P. S., Combustion of a low-volatility fuel in a turbojet combustion chamber—Effects of fuel vaporization, *Trans. ASME* **75,** 7, 1303–1310, Oct. 1953.

An experimental program testing the effect of preheating fuel in gas-turbine-type burners on combustion efficiency is reported. Using a Diesel fuel oil, 37° API, 653° F EP, tests were conducted over a fuel temperature range of 100 to 750 F and air-fuel ratios of 9 to 170. Operating off the burner design point, combustion efficiency increased with fuel temperature from an initial low of 58% to a maximum of 90% at 700 F. Only slight variability of efficiency with air-fuel ratio was observed. The primary causative factor appeared to be the fuel droplet vaporization.

N. A. Hall, USA

3898. Lloyd, P., Combustion in the gas turbine. A survey of war-time research and development, *Aero. Res. Counc. Lond. Rep. Mem.* 2579, 45 pp., May 1946, published 1952.

This paper deals with the development of gas-turbine combustion chambers until 1946. It gives a historical summary and outlines the problems of early development. Both English and German combustion chambers are described, and comparative performance tests are presented together with some development of ramjet combustors. Details of research relating to the flow in atomizers, the process of atomization, and vaporization of hydrofuels are described. In addition, the ignition and burning of fuel sprays as well as flame stabilization problems are analyzed. Finally, mechanical characteristics, coking of fuel, and the performance of the complete chamber are reviewed.

The conclusion is reached that understanding of the component processes is in itself incomplete and that the combustion-chamber design does not lend itself to comprehensive theoretical treatment. Progress is achieved to a considerable extent by experimentation.

This paper presents an interesting survey in a field where rapid progress has been made during the past few years.

H. E. Sheets, USA

3899. Sherman, R. A., Sawyer, R. T., and Keinath, G. E., The combustion of pulverized coal in a water-cooled radiant tube, ASME Ann. Meet., New York, Dec. 1952. Paper no. 52—A-123, 10 pp.

Paper presents a preliminary experimental investigation of a method for burning pulverized coal at rates of heat release of the order of 400,000 Btu per cu ft per hr for steam-locomotive applications. This was accomplished by burning a high-volatile pulverized coal in 5-in. (OD) alloy-steel radiant tubes of 10, 15, and 20-ft lengths, respectively, which were surrounded by 6-in. concentric boiler tubes forming the inside tubes of a water heat exchanger.

Firing rates of 40 to 160 lb coal per hr were used with no slag deposit at rates lower than 80 and a thin layer at the higher rates. The efficiency of combustion (20–40%) was low, but the tests demonstrated that pulverized coal could be burned with very high rates of heat release without slagging difficulties as usually encountered.

A design of a locomotive employing this type of combustion chamber is given. R. E. Bolz, USA

3900. Anselm, W., Vertical cement kilns. Rotating cement kilns (in Spanish), *Inst. tecn. Constr. Cem. Publ.* 116, 26 pp., July 1952.

Vertical kilns and revolving kilns for manufacturing Portland cement are thoroughly treated in two separate papers. The burning process in vertical kilns depends basically on dimensions and type of the kiln, on granulometry of combustibles and raw materials, and on physical and chemical reaction between combustibles and raw materials. Characteristics of kilns during the past 40 years and up to modern types are discussed, especially the position of the sinterization zone (raising from the bottom to the top of the kiln), reduction of burning energy (from 1500 to 1000 kcal per kg of clinker), increase of air consumption (up to 200%), and increase of production (from 55 to 220 tons per day). Other important factors are thoroughly discussed and amply illustrated by diagrams, such as characteristics of injectors, granulation, pressure and amount of air, temperature of air and gas and their velocities, etc. A similar study is presented on revolving kilns having capacities from 400 to 1000 tons per day. Comparative data are of special interest. J. J. Polivka, USA

Heat and Mass Transfer

(See also Revs. 3817, 3836, 3865, 3894, 3899, 3936, 3939, 3941, 3942, 3943, 3945, 3948, 3953)

3901. Tessin, W., and Jakob, M., Influence of unheated starting sections on the heat transfer from a cylinder to gas streams parallel to the axis, *Trans. ASME* **75,** 4, 473–481, May 1953.

Authors studied the effect of hydrodynamic starting length on the rate of heat transfer between a heated cylinder and an air stream flowing parallel to its longitudinal axis, both in the laminar and turbulent region. A description of the testing apparatus is given. In their calculation of the film coefficient of heat transfer, variation of temperature along the heated length is taken into consideration. For flow in the turbulent region, a correlation for Nusselt number based on mean surface coefficient which includes the effects of the starting length can be represented by

$$(N_{Nu})_x = 0.0307(N_{Re})_L^{0.8}(x/L)^{0.91}$$

where x and L are the heated and total length, respectively. An expression for Nusselt number based on local surface coefficient is derived. Within the range of temperature and air velocity studied, vibration control seems to have little effect on heat transfer. On the other hand, a slightly inclined flow shows noticeable influence.

The effect of changing cylinder radius on heat-transfer rate is also discussed.

There are several misprints in the mathematical expressions given. B. T. Chao, USA

3902. de Graaf, J. G. A., and van der Held, E. F. M., The relation between the heat transfer and the convection phenomena in enclosed plane layers, *Appl. sci. Res. (A)* **3,** 6, 393–409, 1953.

Experimental study of heat transmission through a layer of air (6.9, 12.6, 22.9 mm thick) between two solid plates (43 × 43 cm²). The plates can be tilted about a horizontal axis; a steady difference of temperature of 10–100 C is maintained between them, and the heat flow observed is corrected for radiation. Transmission of heat is investigated for vertical, oblique, and horizontal air cushions. Results are formulated and plotted in terms of dimensionless units (Nusselt and Grashof numbers).

Circulation is directly observed by means of an optical method and by introducing smoke into the air layer. In accord with previous authors, it is found that, under suitable conditions, the air cushion breaks up into numerous cells or columns of locally circulating air. A new type of roll-shaped local circulation is described as appearing in oblique air cushions.

R. Eisenschitz, England

3903. Sibulkin, M., and Eber, G. R., On the variation of heat transfer with Mach number in wind tunnels having constant supply conditions, *J. aero. Sci.* **20,** 4, 288–289, Apr. 1953.

Paper shows that constant value of average Nusselt number divided by square root of Reynolds number found in tests of cones in supersonic flow is predicted by both incompressible and compressible laminar-flow solutions for particular conditions of tests. Therefore, conclusion of previous paper [AMR **5,** Rev. 1812] that incompressible solution is adequate under all conditions is not warranted, since compressible theory indicates dependence of Nusselt-Reynolds number relationship on factors (particularly total temperature) not varied during tests.

W. F. Davis, USA

3904. Millsaps, K., and Pohlhausen, K., Thermal distributions in Jeffery-Hamel flows between nonparallel plane walls, *J. aero. Sci.* **20,** 3, 187–196, Mar. 1953.

Viscous, incompressible flow in converging and diverging plane wall channels is considered in virtue of the velocity profiles given earlier by Jeffery and Hamel as exact solutions of the Navier-Stokes equations. The corresponding thermal energy equation is considered and found to be reducible to an ordinary differential equation with variable coefficients. Solution of this ordinary equation is effected numerically for apex included angles of 10° for Reynolds numbers 684–5000 and for Prandtl numbers 0.5–10. The thermal distributions so obtained are shown graphically.

R. M. Drake, Jr., USA

3905. Müller, W., Energy equations for the heat transfer of viscous compressible fluid flow (in German), *Öst. Ing.-Arch.* **7,** 2, 77–87, 1953.

Paper develops various forms of differential equation for energy conservation in compressible media using vectorial and dyadic notation. Application is made to case of damped, single-plane sound waves in an infinite media. D. R. Chapman, USA

3906. Trocki, T., and Nelson, D. B., Liquid-metal heat-transfer system for nuclear power plants, *Mech. Engng., N. Y.* **75,** 6, 472–476, June 1953.

A cursory description of the construction and operation of a steam generation system in which liquid sodium and then sodium-potassium alloy transferred the heat in a stepwise process from an oil-fired heater to the water. The study extended over a period of 3 years. W. L. Sibbitt, USA

3907. Johnson, J. E., Regenerator heat exchangers for gas-turbines, *Aero. Res. Counc. Lond. Rep. Mem.* 2630, 72 pp., May 1948, published 1952.

Paper is concerned with two separate subjects: (a) Analysis of the regenerative or rotating-type counterflow heat exchanger; and (b) test data for screen and plate-type matrixes usable in such a heat exchanger.

Analysis is an approximate one on the lines of a method de-

veloped by Hausen. Method starts from a solution to the problem of initial cooling of a uniformly heated matrix by a steady flow of fluid. A solution to the final regenerator problem is then built up from the initial cooling solution in which the regenerator matrix is assumed to be split into a number of small elements throughout which the temperature is considered to be uniform and varying continuously with time only. Solutions are presented in tabular and graphical form for equal-flow heat-capacity rates and equal blow times, but an approximation for unequal blow times is also presented.

Experimental data, both heat-transfer and flow-friction, are presented for a number of wire screen matrixes, and plate matrixes forming triangular flow passages. These data were obtained in a transient test rig in which the matrix was uniformly heated, and then cooled by air passage, temperature as a function of time of the emerging air being recorded. The data were reduced using a single-blow solution. Numerical examples for application of the regenerator with the test matrixes to gas-turbine plants are also presented. W. M. Kays, USA

3908. Poppendiek, H. F., Transient and steady-state heat transfer in irradiated citrus fruit, *Trans. ASME* **75,** 3, 421–425, Apr. 1953.

This paper presents an analytical study of the thermal structure within citrus fruits that are artificially heated by radiant orchard heaters; this analysis may be utilized to establish more firmly orchard-heating design criteria. Transient and steady-state temperature solutions are derived for an ideal heat-tansfer system consisting of a homogeneous sphere which suddenly receives radiant energy from a point source and loses energy by convection and reradiation to the surroundings. These solutions are compared to a set of experimental temperature measurements within an orange which was transiently irradiated in an orchard.

From author's summary by R. A. Gross, USA

3909. Szombatfalvy, A., The cooling of a fluid flowing in a pipe line (in Hungarian), *Gép* **3,** 11, 510–513, 1951.

Proceeding from the equality of the quantity of heat delivered by the fluid within a unit of time and the quantity of heat conducted away on the surface of the tube, $-Md\tau = A(\tau - T)dt$, where M is heat capacity of the fluid columns, A heat-transfer capacity of the pipe, τ temperature of the fluid, T ambient cooling water temperature, t time, the following formula is deduced for the temperature of the issuing fluid

$$\tau = D\gamma cv(\tau - T)/4e\lambda s + T$$

where D is diameter of the pipe, s length of the pipe, v speed of the flow, λ specific heat-transfer factor, γ and c specific gravity and specific heat of fluid, respectively. Two numerical examples of application are given for the computing of λ for a pipe coil of given dimensions and for the increase of cooling capacity of a pipe coil of given dimensions by raising the speed of flow v, or, if that should not lead to the required results, by changing dimensions d and s of the pipe coil.

Courtesy of Hungarian Technical Abstracts

3910. Gelder, T. F., Lewis, J. P., and Koutz, S. L., Icing protection for a turbojet transport airplane: heating requirements, methods of protection, and performance penalties, *NACA TN* 2866, 57 pp., Jan. 1953.

3911. Lovass-Nagy, V., The mathematical investigation of cooling phenomena (in Hungarian), *Magyar Technika* no. 10, 58–63, 1951.

This study, prepared in the Institute of Applied Mathematics of the Hungarian Academy of Sciences, resolved a problem connected with the heat treatment of the rotor iron cores for turbogenerators, which is of decisive importance for the generation of electric power; namely, how the temperature of any arbitrarily given point of a metal cylinder with given dimensions (limited length) may be computed at a given moment during heating or cooling of the cylinder if the initial thermic state of the cylinder and the ambient temperature are known. The laws for the heat current developing in the interior of the cylinder and for the heat transfer developing on its surface are

$$\delta u/\delta t = a^2\nabla^2 u \quad \text{and} \quad k(\delta u/\delta n) = -h(u - u_0)$$

If the 0 point of the temperature scale is shifted to u_0 and the initial temperature is assumed to be $u_1 = I$, the equation in cylindrical coordinates is, after differentiation and integration, finally given in the form $u(r,z;t) = (u_1 - u) \cdot Z(\xi,\tau)R(\rho,\tau') + u$, where

$$\xi = z/L, \quad \rho = r/r, \quad \tau = (a^2t)/L_2, \quad \tau' = (a^2t)/r^2$$

A numerical example is worked out by means of the deduced formulas, and the isothermic lines of temperature distribution over a cross section of the given cylinder are drafted on the basis of the obtained table. These isothermic lines furnish information on the temperature gradients as well.

Courtesy of Hungarian Technical Abstracts

3912. Jaeger, J. C., Conduction of heat in a solid with periodic boundary conditions, with an application to the surface of the moon, *Proc. Camb. phil. Soc.* **49,** part 2, 355–359, Apr. 1953.

A relaxation method is developed to determine when steady conditions have been attained, the average flux into a semi-infinite solid with thermal properties being independent of temperature and with surface conditions varying periodically with time. Using Laplace transforms, the average flux into a solid during an interval can be obtained when the boundary conditions have period T which is divided into N equal intervals. The result is in terms of a rapidly converging integral which may be evaluated numerically. Numerical results are stated for the case of $N = 20$.

An expression is given for the average flux into a solid during an interval when the surface temperature is a periodic step function. The author states that, for usual cases, boundary conditions consist of N algebraic equations for the periodic step temperatures. A short discussion is given of the accuracy of the method for the case of a sinusoidal surface temperature.

The method is applied to the variation of surface temperature of the moon at the equator during a lunation. A set of curves is given for the surface temperatures of homogeneous solids with various values for the product of thermal conductivity, density, and specific heat.

Extensions are indicated, such as effect of surface skin of negligible heat capacity, and microwave temperature.

The paper presents a numerical method comparatively free of difficulty for calculating over a short time interval the average flux from periodic surface temperatures. The average flux may be replaced by another periodic quantity.

G. A. Hawkins and E. A. Trabant, USA

3913. Lykov, A. V., Theory of conduction of heat [**Teoriya teploprovodnossti**], Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1952, 392 pp.

This textbook for students of the Russian technical high schools is divided into 14 chapters.

First of all come three sections of introductory character explaining physical and mathematical principles of conduction of heat. Chapters 4–7 are devoted to detailed study of temperature

fields without sources, problems being classified according to the most important types of boundary conditions. The following three main parts discuss the idea of sinks and sources and show its significance in solving problems on conduction of heat. Then come questions involving latent heat, experimental methods of determining thermal constants of insulators, cases where thermal coefficients depend upon temperature, and others. The last chapter gives a short account of the Laplace transformation and its use in theoretical conduction of heat.

The volume is based, for the most part, on operational methods and contains valuable information for students and engineers; nevertheless, it should be welcome as giving a broader outlook on various methods applied in mathematical theory of conduction of heat. Mathematician and computing engineer will certainly prefer, in this regard, the well-known work by Carslaw and Jaeger. V. Vodička, Czechoslovakia

3914. Still, E. W., Temperature control of jet-engined aircraft, *J. roy. aero. Soc.* **57,** 506, 89–102, Feb. 1953.

The rapid development of the jet engine has been responsible for a complete change of outlook in air transport. The purpose of this paper is to illustrate some of the problems and to indicate ways in which they have been solved. The subjects discussed are those of temperature control of (1) pressure cabins of aircraft, (2) engine intakes (for deicing), and (3) aircraft wing surfaces (for deicing). From author's summary

3915. Strehlow, R. A., The temperature dependence of the mutual diffusion coefficient for four gaseous systems, *Univ. Wisc., Nav. Res. Lab.*, CM-776, 20 pp., Feb. 1953.

Diffusion coefficients have been measured for the systems He–A, H_2–A, H_2–nC_4H_{10}, and H_2–SF_6 over the temperature range of 13 C to 150 C. The values were determined by a point concentration analysis while diffusion proceeded at one end of a Loschmidt-type cell. The analysis was made with a hot-wire technique and utilized the large difference in thermal conductivity to indicate concentration. The generalized equations for calculating D from an experiment with a Loschmidt-type cell are given, as well as an analysis of the errors involved in calculating D from these data.

The data were used to calculate binary force constants for the Lennard-Jones 6–12 potential. In the system SF 6–H_2, these are $\epsilon/k = 320\ K$ and $(r_0)_{12} = 3.25$ Å. The other three systems fit the theory very poorly. The middle temperature value was about 5% low, relative to the theoretical curve through the high and low data point. The difficulties of calculating Lennard-Jones force constants from experimental viscosity or diffusion data are discussed. From author's summary

3916. Brandstaetter, F., Comments on the method by H. Mache for the determination of diffusion coefficients for air in water (in German), *Öst. Akad. Wiss. math.-nat. Kl. S.B.* IIa **161,** 4–6, 107–130, 1952.

Mache's method for the determination of diffusion coefficients of air in water is based on the observation of the increase or decrease of air bubbles in water saturated with air [*Wiener Ber.* **138,** 529, 1929]. Author discusses the difficulty, that diffusion coefficients determined by this method show an apparent dependence on the radius of the bubble. His conclusion is that this effect is due to the influence of traces of impurities in the water, which influence the passage of the air through the wall of the bubble. H. C. Brinkman, Indonesia

3917. Spielman, M., and Jakob, M., Local coefficients of mass transfer by evaporation of water into an air jet, *Trans. ASME* **75,** 3, 385–392, Apr. 1953.

A previous paper dealt with the heat transfer in the flow of an air jet parallel to a plane plate. The present paper reports on experiments on evaporation from wet porous plates to such a jet. A satisfactory correlation of a modified Nusselt number with a Reynolds number and a starting-length function is presented. The influence of the starting points of hydrodynamic, thermal, and diffusional boundary layers is discussed, with reference to previous work on this subject.

From authors' summary by S. S. Penner, USA

Acoustics

(See also Revs. 3816, 3861)

3918. Schröder, F.-K., Sound absorption as a function of the angle of incidence (in German), *Acustica* **3,** 2, 54–66, 1953.

The reflection coefficient of a plane sound wave is determined experimentally, using a pulse in a flat room at frequencies between 0.9 and 5 kc and at angles of incidence between 0 and 70 deg. The absorbers were porous materials with and without foil facings of different kinds. The results on porous materials agree fairly well with the theory, the ones on resonating devices only qualitatively. F. E. Borgnis, USA

3919. Kuhl, W., The properties of water-filled tubes for the measurement of impedance and sound velocity (in German), *Akust. Beihefte* no. 1, 111–123, 1953.

Thick-walled vertical metal tubes, open at the top and filled with water, were used, the source of sound being placed near the bottom. Disregarding the Poisson ratio of the tube material, author derives a simple approximate expression for the ratio c'/c of the actual speed of propagation of sound in the water in the tube to its value in the unlimited medium in terms of the ratios (volume modulus of liquid)/(Young's modulus of solid) and (external radius r_2)/(internal radius r_1), which is in satisfactory agreement with T. H. Gronwall's expansion [*Phys. Rev.* **30,** 1, 71–83, 1927]. Also considered is the dispersion of c' at very high frequencies due to the variation of sound pressure over the cross section of the tube. Measurements of c' in water in a steel tube, with $r_1 = 2.5$ cm and $r_2 = 4.0$ cm and other tubes at frequencies from 3 to 80 kcps, lead to agreement with the theoretical values to within the experimental accuracy of 0.2%.

The acoustic impedance is measured by analysis of the standing waves produced, obtaining the ratio of pressure maximum to pressure minimum with the aid of a small tourmaline piezoelectric microphone, the results being shown graphically as a function of frequency for the three tubes used.

Measurements in fresh water at 10 kcps and temperatures from 15.5 to 20.5 C yield $c = 1482 \pm 1$ m/s at 20 C, independent of the amount of dissolved air.

This investigation, carried out from 1939 to 1943 but published only now, is similar in several respects to the work done by Fay, Brown, and Fortier [*J. acoust. Soc. Amer.* **19,** 5, 850–856, 1947] on the practicability of a water-filled impedance tube.

R. Heller, USA

3920. Lenihan, J. M. A., The velocity of sound in air, *Acustica* **2,** 5, 205–212, 1952.

Object of the experiments reported was to measure accurately the velocity of sound in free air rather than in a tube. The observations consisted of wave-length measurements of a steady sound of accurately known frequency. Wave length was deter-

mined with the aid of a microphone mounted on a lead screw, successive phase coincidences being observed oscillographically following suitable pulse shaping of the transmitted and received signals. The result obtained, 331.45 ± 0.04 m/s under standard conditions, agrees well with values obtained by other methods.

F. G. Blake, Jr., USA

3921. Mawardi, O. K., and Dyer, I., On noise of aerodynamic origin, *J. acoust. Soc. Amer.* **25, 3, 389–395, May 1953.**

Few other articles have discussed the quantitative aspects of the conversion of the mechanical energy associated with air flow to acoustic noise, a problem of concern to designers of airplanes and their associated installations. Qualitative arguments suggest that, for given similar flow conditions, the spectrum function of the acoustic source and the conversion efficiency should be constants. These are used to correlate noises from wind tunnels, turbojet engines, and air jets. Differences between systems exist in efficiencies and spectra. E. Ackerman, USA

3922. Regier, A. A., and Hubbard, H. H., Status of research on propeller noise and its reduction, *J. acoust. Soc. Amer.* **25, 3, 395–404, May 1953.**

The basic concepts concerning the mechanism of propeller-noise generation are reviewed, and equations for calculating the noise field both near and far from the propeller are given. The problem of noise due to nonsteady airloads on the blades, and differences in noise from the approaching and retreating blades are discussed. Effect of tip speed, number of blades, blade thickness, and blade width are considered, and it is shown that reducing the tip speed and increasing the number of blades are probably the most effective means of reducing the efficiency of noise generation and alleviating the noise problem. Noise characteristics of such special types as the supersonic, dual-rotating, tandem, and shrouded propeller are also presented. Studies show that substantial noise reduction on transport-type propellers would result in a considerable weight penalty. For the propeller-driven aircraft in the 400 to 500-mph speed range, the slower-turning quieter propeller is likely to have better propulsive efficiency than the noisier high-speed propeller. Hence, in this speed range, the weight penalty of the quieter propeller may be offset by its higher propulsive efficiency.

From authors' summary by N. Tetervin, USA

3923. von Gierke, H. E., Physical characteristics of aircraft noise sources, *J. acoust. Soc. Amer.* **25, 3, 367–378, May 1953.**

A knowledge of the physical characteristics of the noise sources is necessary in order to define the magnitude of various aircraft noise problems. Available basic characteristics of different aircraft noise sources for the condition of zero forward speed are summarized; total acoustic power, acoustic mechanical efficiency, directivity and frequency characteristics are given for the rotation and vortex noise of propellers, for the exhaust noise of reciprocating engines, and for different types of jet engines. Some of the mechanisms of noise generation are discussed, and the influence of changes in parameters, such as tip speed of the propeller and diameter or velocity of the gas jets, are shown. In cases where measurements on the actual propulsion systems are incomplete, some conclusions are drawn from experiments on model airscrews and small air jets. The changes in the characteristics of the noise generators during flight are discussed briefly.

From author's summary by H. H. Hubbard, USA

3924. Powell, A., The noise of choked jets, *J. acoust. Soc. Amer.* **25, 3, 385–389, May 1953.**

With supersonic or choked jets, the noise sound pressure may increase with as much as the ninth power of the velocity. At the same time the flow shows a repetitive cellular structure in terms of effective stream diameter. By use of a 0.7-in. × 0.12-in. rectangular orifice, it could be further seen that the cells are initially on the axis, but soon become displaced alternately to one side and the other. The disturbance displacements increase in magnitude downstream until chaotic turbulence is reached. From the number of cells, the directional characteristics of the noise may be calculated. These disturbances in displacements are allied with sound waves radiated both forward and backward; the upstream sound is of lower frequency than the downstream, and there is a 180° phase shift across the jet.

Among suggestions for delaying the onset of the cell disturbance and hence reducing the noise are: Employ a gauze cylinder as a nozzle extension; introduce cambered radial vanes into the flow to set up steady axial vortexes; or nick the exit edge of the nozzle. It is interesting that this latter artifice is used in organ pipes to make them speak with less delay. V. Salmon, USA

Ballistics, Detonics (Explosions)

3925. Travers, S., and Touchard, L., The gun with an internal nozzle (in French), *Mém. artill. fr.* **27, 2, 247–278, 1953.**

Authors continue examination of guns with internal nozzle (Hoch-und-Niederdruck Kanone), reviewed in AMR **6,** Rev. 3589. They study advantages of using proper convergent-divergent nozzles instead of simple cylindrical channels, aerodynamics of the transient flow in the gun, and the maximum velocities attainable. J. Corner, England

3926. Fayolle, P., and Naslin, P., Measurement of short time intervals (in French), *Mém. artill. fr.* **26, 27,** 4, 1, 2; 767–817, 13–75, 281–346, 1952, 1953.

The three papers are a comprehensive and critical survey of the numerous equipments and techniques that are available for the measurement of short time intervals (milliseconds and fractions thereof) of the type commonly encountered in ballistics and shock-wave phenomena. The following division of material is made: Limits of accuracy; fundamental and secondary time standards; electromechanical chronographs; and electronic chronographs. The material is clearly presented and, as indicated by the authors, ought to be extremely valuable to both the experienced and inexperienced investigator in guiding his choice of experimental procedures and in directing his attention to the difficulties and limitations involved in the measurement of short time intervals. The survey is particularly welcome since no comparable survey exists. J. S. Rinehart, USA

3927. Besse, L., Calculus of probability and ballistic applications (in French), *Mém. artill. fr.* **26, 27,** 4, 1; 923–1003, 99–129; 1952, 1953.

In these sections (labeled chapters VI through XI), author continues his detailed exposition of probability theory. Some applications are made to distribution of hits in artillery fire and to quality control of ammunition, but most of this material is pure mathematical exposition. These chapters discuss: Properties of the Gaussian law; convergence toward the normal law; the law of large numbers, and the generalized Bernoulli theorem; Pearson's criterion, and the chi-square distribution; verification and criteria of normality; notions in the theory of sampling, and laws on the distribution of characteristics of samples.

Author emphasizes a number of features sometimes overlooked. Other chapters are to follow. A. A. Bennett, USA

3928. Brosheer, B. C., Pontiac cold-extrudes rocket projectiles, *Amer. Mach.* **97,** 1, 118–120, Jan. 5, 1953.

Soil Mechanics, Seepage

3929. Bishop, A. W., and Gamal Eldin, A. K., The effect of stress history on the relation between ϕ and porosity in sand, Proc. Third inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953, in 3 vols., vol. I, pp. 100–105. SFr 75.

Paper covers series of triaxial tests on medium sand from the Folkestone beds, with samples 1.5 in. round × 3.5 in. long. Undrained and drained triaxial compression tests were carried out with isotropic consolidation, then with anisotropic consolidation, and finally with overconsolidation. Drained compression tests with failure caused by removal of minor principal stress, test on dry sand, and actual existing tests were also performed. As concluded by the authors, the angle of internal friction is independent of the stress history for this material; however, the relation between undrained strength and the consolidation pressure seems influenced by anisotropic consolidation. Reference is made to work by Taylor and others on the same principles, with clay as a study medium, and it is noted that more work is required. The work is of great use for laboratory technicians and designers in regard to the performance and significance of the triaxial tests.

R. Quintal, Canada

3930. Anonymous, The unified soil classification system, Appendixes A, B, *Wwys. Exp. Sta. tech. Memo.* no. 3-357, **1, 2, 3;** 30 pp., 11 pp., 9 pp.; Mar. 1953.

The Unified system of soil classification was adopted by the Corps of Engineers, U. S. Army, and the Bureau of Reclamation in January 1952. The base of the Unified system is the Casagrande system of soils classification, tentatively adopted by the Corps of Engineers in 1942 [see *ASCE Trans.* **113,** p. 901, 1948].

The scope of the Unified system is broader than the Casagrande system, the former being intended to apply to embankments, foundations, roads, and airfields, while the latter was intended primarily for airfields.

The two systems will appear to be quite similar. Both divide soils into three principal divisions: coarse-grained, fine-grained, and highly organic. Each divides the coarse-grained division into 8 groups, the fine-grained division into 6 groups, and each lumps the organic soils into one group. Both rely heavily on a description of the soil, in addition to the group symbol. Both allow for borderline cases by the use of dual symbols.

The dividing lines between major categories within the unified system are arbitrarily defined to coincide with a U. S. Standard sieve size. For example, the coarse-grained soils are defined as those wherein more than half the material is larger than no. 200 sieve size. Gravels are defined as those coarse-grained soils where more than half of coarse-grained fraction is larger than no. 4 sieve size. Similarly, sands are those where more than half the coarse fraction is smaller than no. 4 sieve size.

The Unified system distinguishes between coarse-grained soils by (1) two empirical coefficients based on gradation: the uniformity coefficient ($=D_{60}/D_{10}$), and a coefficient of curvature [$= (D_{30})^2/D_{60} \times D_{10}$], and (2) Atterberg limits of the binder, if present. (The binder is defined, in accordance with Casagrande, as the fraction passing a no. 40 U. S. Standard sieve.)

Fine-grained soils are classified on the basis of their Atterberg limits, supplemented by observations of dry strength, reaction to shaking test, and consistency near plastic limit.

Highly organic soils are separated from the coarse-grained and fine-grained divisions by means of visual examination, where the highly organic soils are identified by their color, odor, spongy feel, and, sometimes, fibrous texture.

The report contains much practical information on methods for field examination of soils and gives examples of typical soils in the various categories. Appendix A is devoted to the application of the system to embankments and foundations, and Appendix B applies the system to roads and airfields.

The Unified system is probably not the final word in soils classification for engineering purposes. It does establish definite, if arbitrary, boundaries between the various divisions. It is by no means, however, an absolute system in which each soil fits neatly into a unique category. Much reliance still must be placed on experience and judgment.

The scope of the system is very broad, and there is little doubt that much practical experience must be gained with the system before its usefulness in all the intended engineering applications will be known.

D. M. Vestal, Jr., USA

3931. Jáky, J., Network of slip lines in soil stability, *Acta Techn. Hung. Budapest* **6,** 1/2, 25–38, 1953.

Paper examines some simple solutions of equilibrium equations with Coulomb's failure condition, to determine active pressure on retaining wall. On the assumption that there is only one surface of failure passing through heel of back of wall, the conditions under which slip surfaces are plane or logarithmic spiral are obtained.

A failure surface comprised of a plane and a curved surface (similar in shape to logarithmic spiral) is also found to be consistent with governing equations, but calculation of active earth pressure on this basis gives numerical values very close to those obtained, assuming plane surface of slip.

R. E. Gibson, England

3932. Pore pressures in rolled fill earth dams, *Trans. So. Afr. Instn. civ. Engrs.* **3,** 4, 113–121, Apr. 1953.

In the first part of the article, author discusses the effect of excess hydrostatic pressure gradients on the stability of slopes. The second part deals with pore pressures in large dams during construction.

It has been proposed by Hilf, in a paper submitted to the Second International Conference on Soil Mechanics, 1948, to determine by laboratory tests on soil samples the pore pressure expected in building a dam. Unfortunately in some cases, considerable discrepancy was observed between pore pressure in tests and in dams during construction.

Author gives three methods for designing earth dams. (1) Estimate the expected pore pressure on the basis of prior laboratory tests on soil samples. (2) Use the results of pore-pressure measurements on previous dams. (3) "Design-as-you-go" method.

As laboratory tests have not always proved reliable, and pore pressure in other dams has not always been comparable, author thinks the third way is the best and most scientific. In this method, preliminary investigations are made and followed by design, which is kept flexible, so that adjustments can be made in the course of construction as and when pore pressures, that are measured during construction, show signs of building up to dangerous intensities.

F. C. de Nie, Holland

3933. Scott, P. P., Jr., Bearden, W. G., and Howard, G. C., Rock rupture as affected by fluid properties, *J. Petr. Technol.* **5,** 4, 111–122, Apr. 1953.

Review is given of various theories of failure pertaining to rupture of thick-walled cylinders of homogeneous, isotropic, impermeable material. Series of experiments is described where

cylinders of neat cement, samples of limestone, sandstone, and shale cores from subsurface formations were ruptured by internal pressure. Pressure observed to rupture rock was compared to pressure calculated to cause inelastic action in accordance with various theories of failure. Authors list some of the physical properties that influence the resulting rupture pressure.

Authors discuss the distribution of stresses due to the earth's overburden. An attempt is made to calculate stresses that would act on surface of well bore due to earth's crust. An interesting discussion of such possible stress distributions is given by M. King Hubbert. J. Aronofsky, USA

3934. Hammond, R., Resilient forge foundations, *Metal Treatm.* **20,** 88, 15–22, Jan. 1953.

Details are given of a method of mounting forging hammers on resilient foundations to minimize the heavy shocks and vibrations which can lead to failure of conventional foundations or affect adjacent buildings or machinery. All parts are visible and accessible for maintenance without the necessity for dismantling. From author's summary

3935. Nascimento, U., Investigation on the control and protection of the soil foundations of Luanda (in Portuguese), *Minist. Obras. Públ., Lab. Engen. civ. Lisboa Pub.* no. 30, 34 pp., 1952.

Micromeritics

3936. Chu, J. C., Kalil, J., and Wetteroth, W. A., Mass transfer in a fluidized bed, *Chemical Engng. Progress* **49,** 3, 141–149, Mar. 1953.

When mass transfer data are correlated in terms of the Chilton-Colburn group j_D and the Reynolds group D_pG/μ (D_p particle diameter, G superficial mass velocity, μ viscosity), different curves are obtained for fixed and fluidized beds, while the particle diameter seems to occur as a parameter. Results of various investigators are not very consistent. Gamson [title source, **47,** 19, 1951] succeeded in obtaining one single correlation for fixed and fluidized beds, in which, moreover, particle size does not occur as a parameter, by plotting $j_D/(1-\epsilon)^{0.2}$ vs. $Re_* = D_pG/\mu(1-\epsilon)$, where ϵ is bed voidage.

Reassessing data of other investigators and combining them with his own data (system naphthaline-air, cylindrical Celite catalyst carriers, lead shot, rape seed, and small glass beads), author shows that a slight improvement can be gained by plotting j_D alone against Re_*. Yet the spread of data is more than $\pm 50\%$ around the curve. The following correlations are proposed for the streamline and turbulent region.

$$j_D = 5.7\ Re_*^{-0.78};\ 1 < Re_* < 30$$

$$j_D = 1.77\ Re_*^{-0.44};\ 30 < Re_* < 5000$$

Further, an attempt is made to extend the Chilton-Colburn analogy of mass transfer and pressure drop for flow in conduits to the case of fixed and fluidized beds. Taking the Carman-Kozeny friction factor f for fixed beds, a plot against Re_* gives a curve similar to that of j_D against Re_*. If the two curves are made to coincide at $Re_* = 10$ and 1000, the relation $j_D = f/10$ is obtained ($j_D = f/2$ for pipe flow). No physical interpretation is given. Beyond the above Re_* values, deviations occur (j_D 30% too high at $Re_* = 100$, and 40% too low at $Re_* = 5000$).

J. O. Hinze, Holland

Geophysics, Meteorology, Oceanography

(See also Revs. 3673, 3674)

3937. Satô, Y., Velocity of elastic waves propagated in media with small obstacles, *Bull. Earthq. Res. Inst., Tokyo Univ.* **31,** part 1, 1–17, Mar. 1953.

As in the previous paper [AMR **6,** Rev. 1835], author assumes that the obstacles in a medium are spherical bodies. Now, solid obstacles are considered instead of holes filled with a liquid under similar conditions (large number of obstacles located in a small part of the whole volume). Using expressions for displacements and stresses in terms of spherical harmonics and an "equivalent" homogeneous medium, the unknown coefficients are found from the boundary conditions. Two equations, for the bulk modulus and the rigidity, are derived and some examples of variations of elastic constants and velocities of compressional and shear waves are given. These variations depend on the proportion of volume occupied by obstacles. W. S. Jardetsky, USA

3938. Charney, J. G., and Phillips, N. A., Numerical integration of the quasi-geostrophic equations for barotropic and simple baroclinic flows, *J. Meteor.* **10,** 2, 71–99, Apr. 1953.

Several progress reports by the "Charney School" in a program whose ultimate objective is numerical weather forecasting by automatic calculating machine have been abstracted previously [AMR **4,** Revs. 945, 3737; **5,** Rev. 1245; **6,** Revs. 311, 1771]. They made essential progress and their results are now accepted among the world-wide meteorologists.

Authors derived an n-level generalization of the $2^1/_2$-dimensional model by specialization of the complete three-dimensional quasi-geostrophic equations. In the case $n = 1$, it reduces to the two-dimensional single-layer barotropic model; while in the case $n = 2$, it reduces to the $2^1/_2$-dimensional double-layer barotropic model. Methods of numerical integration of the 2- and $2^1/_2$-dimensional equations, and the machine applications for such integrations, are fully discussed.

The results of a series of six two-dimensional and six $2^1/_2$-dimensional forecasts for 12 and 24 hr are presented. Correlation coefficients (ranging about $0.6 \sim 0.9$) and relating statistical parameters show that there is a consistent superiority of the $2^1/_2$-dimensional over the two-dimensional forecasts, both for 12 and 24 hr. Further, a method of integration is proposed for the n-level generalization of the $2^1/_2$-dimensional model, and computation schemes are outlined for the general three-dimensional quasi-geostrophic equations. The semi-Lagrangian coordinate system with potential temperature as vertical coordinate is shown to exhibit favorable properties for machine integration. [Recent news from Princeton reported the $3^1/_2$-dimensional (three-layer barotropic model) forecasts are noticeably superior and are applicable for routine weather forecasting.] An excellent paper. H. Arakawa, Japan

3939. Stern, M. E., and Malkus, Joanne S., The flow of a stable atmosphere over a heated island, part II, *J. Meteor.* **10,** 2, 105–120, Apr. 1953.

A theoretical investigation is made of the extent to which the flow of a stable air stream over a flat heated island is modified by the presence of the island, and criteria are developed to explain the formation of cumulus cloud trains frequently observed to the lee of such islands. This investigation is primarily concerned with the mechanism involved in the transfer of heat from the heated island to the overlying atmosphere, and it extends a previously presented paper wherein an overly simplified model of heat transfer was taken as a rectangular pulse in the horizontal, coin-

ciding with the extent of the island, whose amplitude decreased exponentially with height [AMR 6, Rev. 2952]. The much more realistic model presented in this paper is based on the vertical transfer of heat by small-scale eddy conductivity. It is shown that the solution of the combined equations representing eddy heat transfer and the vertical displacement of a streamline from its undisturbed level upwind of the island leads to a streamline displacement which can be "divided into two components, one obeying the equation for air flow over a mountain ridge and the other obeying a heat-conduction equation, the latter being important only in the near vicinity of the island." By the use of this equivalent mountain, which depends upon the temperature distribution along the surface of the island, the wind speed, ground-layer eddy conductivity, and the undisturbed stability in the air flowing over the island, it was possible to make theoretical computations of the wave lengths of the cumulus trains and of the strength of the sea breeze which agreed well with observation.

Reviewer believes that this is an excellent example of the type of research needed in meteorology, where the atmosphere itself can serve as a laboratory for the isolation and study of atmospheric processes. J. R. Gerhardt, USA

3940. Hudson, H. E., Jr., Stout, G. E., and Huff, F. A., Rainfall studies using rain-gage networks and radar, *Proc. Amer. Soc. civ. Engrs.*, **79,** Separ. no. 178, 26 pp., Mar. 1953.

The results of three years' study on concentrated rain-gage networks and on measurements of rainfall extent and intensity by means of radar are described. The orientation, duration, and path of storm cells are shown to have marked effects on area-depth curves for a given basin in Illinois. The effects of gage density on mean rainfall errors are studied. Relations between storm type and resultant rainfall in Illinois are discussed.

Data collected in the study on radar signal strength and rainfall intensity are presented and analyzed, using a new analytical approach. Author concludes that radar is able to depict rainfall extent better than rain gaging, and that radar can measure rainfall intensities as ably as the rain-gage networks generally used. Reviewer believes that concrete conclusions with their application in the field of hydrometeorology are provided in this paper.

From authors' summary by H. Arakawa, Japan

3941. Itoo, K., On the growth of ice crystals in the air, *Pap. Meteor. Geophys.* **2,** 3–4, 315–316, Dec. 1951.

3942. Itoo, K., Forms of ice crystals in the air—On small ice crystals (II), *Pap. Meteor. Geophysics.* **3,** 3, 207–216, Jan. 1953.

3943. Itoo, K., Size, mass and some other properties of ice crystals in the air—On small ice crystals (III), *Pap. Meteor. Geophysics.* **3,** 4, 297–306, Mar. 1953.

3944. Cressman, G. P., An application of absolute-vorticity charts, *J. Meteor.* **10,** 1, 17–24, Feb. 1953.

The analysis and use of charts of absolute vorticity are described. Measurements from a winter and a summer series of maps gave 608 and 641 mb, respectively, as the pressure at the mean equivalent barotropic surface. It is shown that, on charts near the equivalent barotropic surface, the absolute-vorticity patterns give indications useful in short-range forecasting, since the lines of constant absolute vorticity are advected with nearly the speed of the wind. Examples are presented, showing typical contour and vorticity patterns for a rapidly moving pattern, a stationary pattern, and a situation of rapid trough development. From author's summary

3945. Jehn, K. H., and Gerhardt, J. R., Surface atmospheric heat-flux analysis on the Lettau model, *J. Meteor.* **10,** 1, 10–16, Feb. 1953.

Determinations of the turbulent flux of heat at the earth's surface are made for the period January 24–25, 1950, at Manor, Texas, with use of mean vertical gradients of air temperature and wind speed, following the Lettau model of nonisotropic turbulence. Simultaneous measurements of net radiation at the surface and of heat interchange in the soil give independent measures of the eddy heat flux, which show reasonable agreement with theory under certain conditions. It is shown that these conditions are apparently such as to require the use of representative values of the potential-temperature difference over a height interval in the surface layer during daylight hours, and of the ratio of mean wind to adiabatic wind at a level in the surface layer at night. It is further observed that the use of the temperature profile in the computation of net heat flux during night hours gives rise to values of negative heat transfer greater in magnitude than the theoretical critical limits. From authors' summary

3946. Palmer, C. E., The impulsive generation of certain changes in the tropospheric circulation, *J. Meteor.* **10,** 1, 1–9, Feb. 1953.

Evidence is presented to show that high-level tropical cyclones originate over the Marshall Islands as tropospheric responses to sudden increases in the radiative output of the sun. Corroboration of the hypothesis that the effect occurs at other longitudes in the tropics is derived from the work of Riehl, Yeh, and La Seur, and the implication is made that changes in the general circulation of middle latitudes follow the poleward migration of the cyclones.

The first response of the troposphere, following solar explosions with a delay probably less than 36 hr, is a sudden rise of temperature in the layer between 300 mb and the tropopause over the equatorial convergence zone. The rate of rise is 7C per day at 100 mb. The changes cannot be explained by advection. Cyclones develop on the poleward side of the upper warm ridge produced by the local temperature rises.

It is suggested that, during solar flares, ultraviolet radiation of greatly enhanced intensity penetrates the ozonosphere near the equator; the absorbent is tentatively identified as water vapor.

From author's summary

3947. Wahl, E. W., Singularities and the general circulation, *J. Meteor.* **10,** 1, 42–45, Feb. 1953.

The association of local or regional weather "singularities" with the state of the general atmospheric circulation is described. The concept of "primary singularities," reflecting characteristic features of the general circulation, and their effect on local or "secondary singularities" is discussed, with principal respect to the Boston daily record of temperature and precipitation.

From author's summary

3948. Björgum, O., On the velocity, temperature, and humidity profiles in the lower atmosphere, *Quart. J. roy. meteor. Soc.* **79,** 339, 84–93, Jan. 1953.

On the basis of the assumption that the eddy viscosity, eddy conductivity, and eddy diffusivity are determined by the first and second differential coefficients of the mean velocity U, mean potential temperature Θ, and mean humidity X, formulas valid up to a height of about 25 m are obtained for U, Θ, and X in terms of height above the ground. These formulas are discussed in relation to the available observational material.

M. V. Wilkes, England

3949. Pône, R., Stability criteria of air layers (in French), *J. sci. Météor.* **4**, 16, 126–134, Oct.-Dec. 1952.

Criteria are proposed for the conditions for stability or instability of air layers—e.g., the atmosphere. The approach is qualitative and is derived primarily from considerations of the effects of variation of temperature and temperature gradient across a layer on the vertical circulation. The proposed criteria are illustrated schematically on pressure-temperature diagrams.

C. Gazley, Jr., USA

3950. Dady, G., Variations of temperature and pressure in the troposphere (in French), *J. sci. Météor.* **4**, 16, 117–125, Oct.-Dec. 1952.

Author discusses the application of simple statistics for correlating pressure and temperature observations in troposphere. Data include 365 radiosonde observations over a period of one year in one locale. He applies multiple correlation techniques relating isobaric surfaces to temperature, thus obtaining significant measures of influence of temperature variations in different strata on pressure at ground level and at specified altitudes. Estimates of probable reliability of deductions are presented.

J. M. DallaValle, USA

3951. Charney, J. G., On the scale of atmospheric motions, *Geofys. Publ. Norske Vid.-Akad. Oslo* **17**, 2, 17 pp., 1948.

In the first section of this work it is shown that the geostrophic deviation is negligible for the primary large-scale perturbations of the atmosphere. If the horizontal divergence, which cannot be evaluated by means of the geostrophic wind, is excluded, it is shown that the geostrophic wind can be used to approximate the horizontal velocity field in all other terms in the equations of motion. In the second section it is clearly shown that the large-scale motion of the atmosphere is governed by the laws of conservation of *potential temperature* and *absolute potential vorticity*, and by the conditions that the motion be in *hydrostatic* and *geostrophic* equilibrium. Next it is shown by a number of illustrations that the simplified system *does* filter out the meteorologically insignificant wave components from the equations for barotropic and baroclinic motion. If these simplified equations are used, the numerical integration presupposes only a knowledge of the initial pressure field, a field which is given directly by available radiosonde data. Lastly, it is shown that the tendency equation must be regarded not as an instrument for calculating pressure tendencies, but as a useful tool for calculating the speed of propagation of the large-scale atmospheric disturbances.

H. Arakawa, Japan

3952. Sakuraba, S., A note on the transformation of kinetic energy by large scale eddy stresses, *Geophys. Mag., Tokyo* **24**, 2, 117–121, Nov. 1952.

Investigation is made of transformation of energy of planetary wind into energy of large scale eddies. Eddy kinetic energy equation is derived with work against gravity included. Result is obtained that the greater part of energy supply from large-scale eddy stresses is dissipated by a stable stratification of the atmosphere; this is different from method of small oscillations applied to a planetary wave. Main conclusion is that, to examine the possibility that the kinetic energy of cyclone or wavelike disturbances in the westerlies aloft is obtained from the energy of the planetary wind, account must be taken of the work against gravity.

N. Tetervin, USA

3953. Sakuraba, S., On the change of potential energy in a cyclone, *Geophys. Mag., Tokyo* **24**, 2, 109–116, Nov. 1952.

It is argued, on theoretical grounds, that the release of latent heat of condensation can supply enough energy to permit both the kinetic and potential energy of atmospheric systems to increase simultaneously in some cases.

L. Machta, USA

3954. Masuda, Y., On the small perturbations superposing upon the circular vortex, *Pap. Meteor. Geophys.* **3**, 2, 138–156, Aug. 1952.

Smaller perturbations are found within the general structure of tropical storms, as seen from analysis of pressure, rainfall, and vorticity fields. Author considers these to be of wave character and attempts to find theoretical expressions for their shape and propagation.

H. Riehl, USA

Lubrication; Bearings; Wear

3955. Charnes, A., Saibel, E., and Ying, A. S. C., On the solution of the Reynolds equation for slider-bearing lubrication, III, *Trans. ASME* **75**, 4, 507–513, May 1953.

Authors consider the effect of transverse curvature on the film lubrication of a rectangular slider bearing, allowing for side leakage. The solution obtained to the Reynolds equation without transverse curvature, assuming a film thickness varying exponentially in the direction of motion [AMR **5**, Rev. 1594], is modified by a perturbation technique to allow for the effect of symmetrical curvature in the transverse direction.

The method appears to be sufficiently accurate for a ratio of edge-to-center film thickness up to 1.40. A numerical example shows a decrease in load capacity and friction for a convex slider.

W. O. Richmond, Canada

3956. Barwell, F. T., and Milne, A. A., Criteria governing scuffing failure, *J. Inst. Petrol.* **38**, 344, 624–632, Aug. 1952.

The lubricant is not considered a constructional gear material in design because knowledge of gear lubrication is inadequate. Empirical lubrication failure concepts are reviewed, and it is suggested that the sliding component in gearing is mainly responsible for surface damage. Experimental checks of existing criteria and pertinent observations were made, using flat-ended rectangular pegs sliding against flat surfaces, including a reciprocating slider and also a rotating disk. The study produced a tentative theory of failure indicating that at "some critical condition of load and speed depending on the rubbing combination, the increased temperature will lead to a change in area of contact, coefficient of friction, or other factor, sufficient to cause an unstable temperature system rising until the melting point of the material is reached." When possible, gears should be designed to favor fluid film conditions; however, limiting gear loads can be increased by attention to surface finish and material.

The reviewer questions the applicability of the data to gear failure problems and the various gear correlation expressions because the authors' experimental conditions (e.g., low surface stresses) place unwarranted emphasis on the hydrodynamic component. The "unstable temperature system" probably occurs only after incipient failure of the boundary lubricating film causes increased and unstable friction. Blok's critical temperature relationship [Proc. Gen. Disc. Lubrication; *Instn. Mech. Engr.* **2**, 14, 1937] expresses a factor for the influence of the oil that may be related to the point of incipient failure.

R. L. Johnson, USA

3957. Macks, E. F., and Nemeth, Z. N., Comparison of high-speed operating characteristics of size 215 cylindrical-roller bearings as determined in turbojet engine and in laboratory test rig, *NACA Rep.* 1084, 12 pp., 1952.

Investigation reports a continuation of work at NACA Lewis

Laboratory on the operating characteristics of a test bearing by a comparison with an actual turbojet-engine bearing. From theory and test, inner- and outer-race cooling-correlation curves were obtained for the turbojet-engine roller bearing with the same inner- and outer-race correlation parameters and exponents as those determined for the laboratory test-rig bearing. A method is given that enables the designer to predict the bearing temperatures from single curves.

The turbojet-engine roller-bearing inner-race temperatures were 30 to 60 F higher than the outer-race-maximum temperatures; these results were opposite to the test-rig results. The effect of oil viscosity on the engine roller-bearing temperatures was significant; with the lower viscosity oils, the bearing race temperatures were markedly less.

The report is excellently prepared and presented.

J. J. Ryan, USA

Marine Engineering Problems

3958. Allan, J. F., Improvements in ship performance, *Trans. Inst. mar. Engrs.* **65,** 5, 117–124, May 1953.

Author surveys improvement of ship performance over the past 25 years and finds that advances are attributable to (a) increase in efficiency of main propulsion machinery, (b) gains from better hydrodynamic design, (c) improvements in structural design and materials. The paper is chiefly concerned with hydrodynamic effects.

In evaluating the comparative resistance of ships as determined from model tests, the author correctly emphasizes that account must be taken of the fact that laminar flow phenomena have, in the past, given rise to low drag results which have often been wrongly ascribed to changes in geometry. He states that data obtained in England prior to 1948 must be corrected for this effect, but he does not state how this is done.

For deep-sea merchant types, author finds that there have been definite gains in designing bow and stern for reduced wave drag, but that this is accomplished without bow bulbs in the range of economically feasible speeds. In the range beyond those considered to be economically justified, reductions up to 10% of the resistance can be achieved with a suitable bulb at the forefoot. Comments are given on the present-day practices for cross-channel, coaster-type, and trawler designs. Paper gives brief summary of the state of knowledge on skin-friction for surfaces with roughness in the "small" (fouling) and in the "large" (structural). Author claims that improvements in design of rudder and stern post design have brought about gains of 8 to 12% in performance of single-screw vessels. Recommended clearances between stern frame and propeller are cited. A fine streamlined post with unbalanced streamlined rudder is stated to give the best performance, and the benefits from contra-flow designs are disclaimed on the basis of carefully conducted model tests on reasonably large scale. Reviewer doubts that influence of rudder and stern post design can be definitely established from model tests in which only the total hull drag and propeller thrust are measured.

The main dimensions of marine propellers are still determined from charts such as Taylor's and Troost's. However, the detailed section design is increasingly made to depend on vortex theory and empirical lift and drag data. Brief mention is made of "wake"-adapted propellers in which modern sections are set to match the local inflow conditions and thus achieve smooth leading-edge flow (so-called "shockless" flow, a misnomer used by naval arcihtects) without pressure peaks. On the whole, it appears that modern propeller design is responsible for about 5% increase in efficiency. Comments are made on hull vibration as induced by propeller action in the hull wake. This topic is of immediate concern in ore-carrier and certain naval types and should be dealt with in greater length, since relatively few naval architects pay much attention to afterbody fullness.

Author describes measures adopted to improve sea kindliness and emphasizes the need for intensive research in this domain. He concludes with a summary of gains which total to an average improvement of 25% and an interesting comparison of the performances of the SS Queen Mary and the SS United States, as presenting the cumulative effect of developments in the past 25 years.

Dr. Allan's fine paper together with its references should be intensively studied by both students and practitioners in the field of naval architecture.

J. P. Breslin, USA

3959. Technical progress in shipbuilding during 1952, *Shipbuilder* **60,** 533, 3–10, Jan. 1953.

3960. Technical progress in marine engineering during 1952, *Shipbuilder* **60,** 533, 11–15, Jan. 1953.

3961. Arnold, A. G., The burning of boiler oil in two- and four-stroke cycle Diesel engines and the development of fuel injection equipment, *Trans. Inst. mar. Engrs.* **65,** 3, 57–81, Mar. 1953.

Boiler oil was burned in five different types of marine diesels to save on the cost of fuel. The resulting experiences and the necessary changes in the engines and fuel systems are given. Results include fuel consumption, cylinder wear, indicator cards, ring replacements, and pictures of pistons and injection nozzles. The boiler oil varied considerably, since it came from ports over the world; even so, the conclusion is that it was burned satisfactorily. Another conclusion is that the maintenance charges are reasonable.

A. O. Flinner, USA

Please Note

The Subject and Author Indexes to APPLIED MECHANICS REVIEWS, Vol. 6, January-December, 1953, are to be published in separate pamphlet form and will be mailed together with the February, 1954, issue of APPLIED MECHANICS REVIEWS.

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